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WAVETEK

**400A Digital
Indicator**

Service Manual

WAVETEK

*Reference
to Doris
400A*

400A Digital Indicators (MDL 400-HBK2)

Service Manual

WAVETEK

Instruments Division

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Introduction

All Series 400A indicators accept a variety of inputs (thermocouple, voltage, current, resistance) and converts them to degrees or other engineering units. Dual slope integration is used for low noise and auto-zero circuitry assures drift-free performance.

The instrument utilizes (LSI) PMOS semiconductor technology. All digital logic including thermocouple and RTD linearization tables is contained in one of two optional ion-implanted PMOS integrated circuits. A solid-state planar LED display is driven by on-chip decoders. Strobes provide a bright digital indication in degrees Fahrenheit or Celsius, or other engineering units.

Dual Slope A/D Conversion

Refer to the schematic of analog circuits (Figure 1) and diagram of dual slope technique (Figure 2). Before each conversion (T_0), S2 and S3 are closed. The auto-zero and zero-cross detector circuits "close the loop" around the integrator, establishing a starting point for the integration.

During T_1 , S₂ and S₃ are opened, S1 is closed and the integrator is allowed to ramp up (down for the $+E_{IN}$). After a known number of clock pulses S1 is opened, S2 is closed, and a short pause occurs to settle capacitor charging.

During T_3 , S5 is connected (S4 if $+E_{IN}$) and the integrator ramps back toward zero at a constant rate. The amount of time (counts) required to return to zero is proportional to the input voltage. After zero-crossing the system returns to auto-zero.

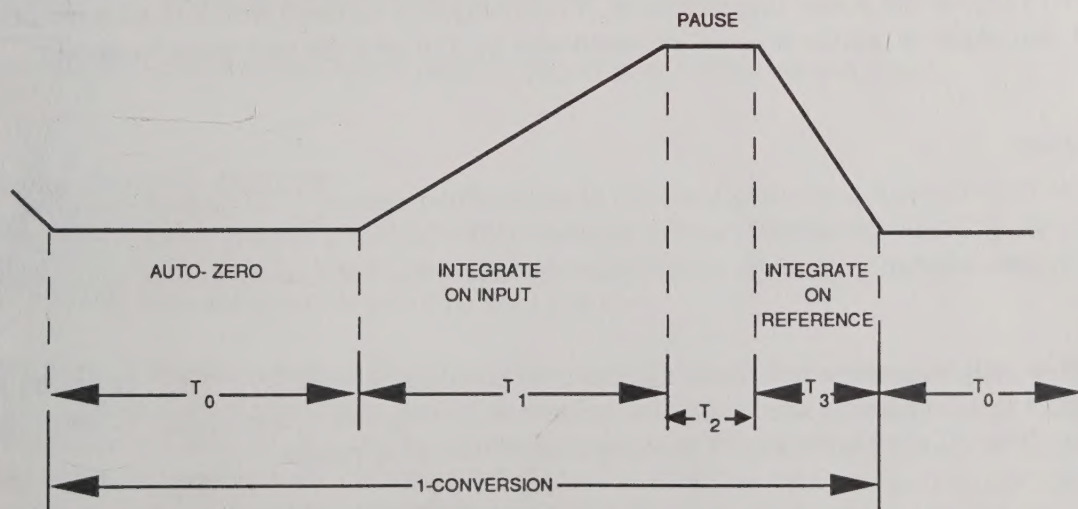


Figure 1. Dual Slope Technique

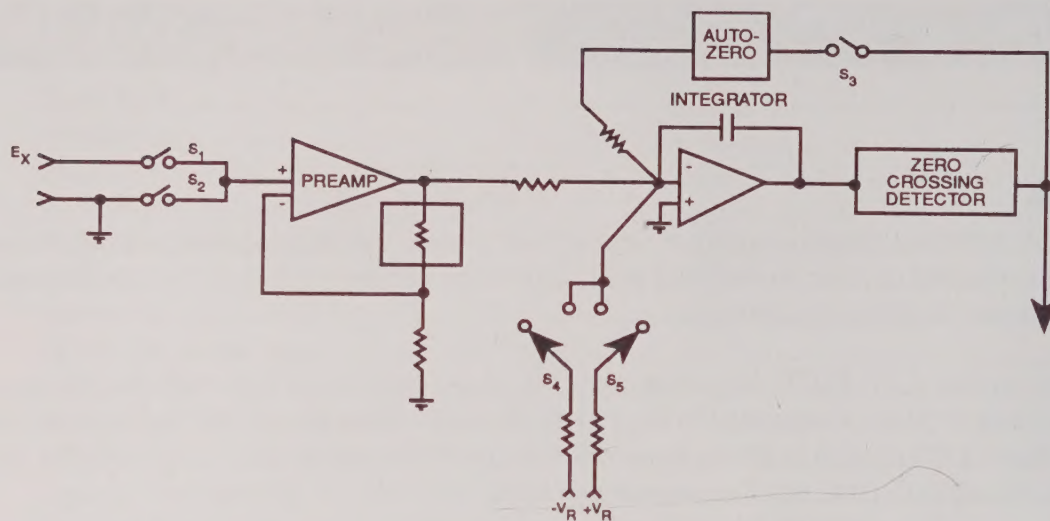


Figure 2. Analog Circuits Showing Auto-Zero

Circuit Description, Base Unit

Power Supply and Regulator

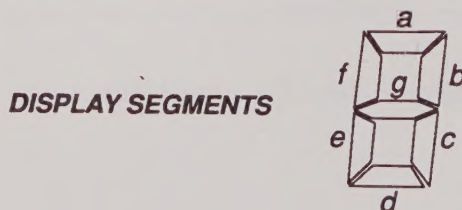
Refer to schematic 400-6180 or 400-6190 in back of manual. AC power is connected at P1, filtered for RF1, and connected to the power transformer, T1. The rectified secondary voltage provides +11VDC on C4 and C5 (LED display power) and -11VDC on C6. The two amplifiers of Z8 drive pass transistors Q1 and Q2. If excessive current is drawn through Q1 or Q2 resistors R3 and R9 limit the peak currents, thus protecting the supply.

Potentiometer R13 adjusts the power supply voltage. Positive span is adjusted with R45 with the front panel removed, and negative span is adjusted independently by R14 with the rear cover removed.

Display and Driver

The seven segments (a through g, see sketch below) of the common-cathode LED displays are driven by seven emitter-follower Darlington transistors (Q9 through Q15). Current is limited by Z11 (resistor network) to illuminate segments a through g. Z10 provides digit drive and selection at the appropriate multiplex time.

Level shifter Q8 is used for leading zero blanking control in conjunction with S2. "DIP" switch S2 is used to select drive to an appropriate decimal point for the range being used. One pole of S2 may also be used to configure °F or °C display for any of the temperature measuring ranges.



Digital Logic

Z9 is a PMOS digital integrated circuit operating from the regulated +7.2 and -7.2 voltages. Pins 15 through 20 are digit strobes for driving digit selection drivers. Pins 23 through 29 provide segment data for generating display. Pin 6 of Z9, a clock input, receives the 400kHz clock, generated by C18, R38, R39 and Z7 pins 11-15. Pin 33 is a power-on reset pin used in conjunction with R41 and C21. Pin 33 clears internal logic and prepares the dynamic logic for the first conversion. Pin 35 is the "start convert" line and delays conversion by a time constant generated by Q7, R40 and C20. Pins 37 through 40 provide the A/D conversion switching logic (see block diagram Figure 2) for S5, S4, S3, and S1. Pins 6 through 9 of Z9 are used in conjunction with the analog program module (J3) to configure the unit for the appropriate range type.

Analog Operation

The Analog Program Modules (APM) condition, scale, and offset various range inputs. For thermocouples a reference junction, gain scaling and break detection circuitry are provided. Current sources and bridge completion are included for PT, CU and TH ranges. Scaling and filtering for K ranges, and shunt and offset circuitry for I ranges are also provided.

The input filter consist of R15, R46, R47, and C9, C10, and C11. The input to Z2 is alternately switched from the filtered input to R17. Potentiometer R19 gives an adjustable low level offset through voltage divider R18 and R17. R21 and R20 provide offset adjustment for low level preamplifier Z2. Gain feedback resistor is contained in the APM between APM pins 2 and 23. R25 and R33 provide reference current for reference integration as switched by Z3. C22 compensates Z4 (400's). Z5 is the auto-zero preamplifier, R34 and R35 set the gain for Z5. R31, R32, and C14 are compensation and hold components for auto-zero error correction. Pins 8 and 9 of Z3 provide S3 switching function. R29 adjusts the DC level and R30 provides the bias for Q6, a source follower. R24 couples the error correction to the summing node. Q3 and the APM generate reference junction correction current for thermocouple ranges. This current and bridge completion offsets for other ranges, are fed from the APM pin 8 to the integrator summing node via series CMOS switch. Z6 and Z7 pins 10 and 9, plus positive feedback (hysteresis) resistors R36 and R37 comprise the zero crossing detector circuitry.

I/O connector P2 provides interface connections for power pack and all other options.

Power Packs (Models 406/407)

Refer to schematic 406-6200 or 407-6100 in Section 4 of this manual. The two power pack options contain circuitry for float charging the sealed lead-acid cells, as well as circuitry for converting the battery voltage into a usable form for the main board power supply.

C1, C2, CR1, and C3 provide a voltage doubling of the raw AC signals from the transformer on the main board. Z3 is a protected constant voltage regulator, which is trimmed to the nominal charge voltage of 11.75V at the anode of CR4. R1, R2, and R3 adjust the voltage of Z3, and CR4 protects Z3 from battery current when not in a charging mode. Switch SW1 disconnects the battery from loads in the "OFF" position (open). Resistors R4 and R5, and Op-Amp Z1 pins 12, 13, and 14 put a "trickle" load on the battery to sense low voltage. If the unit is on, and the battery drops below about 9.3V, LED CR8 is turned on and current limited by R7. The raw battery voltage is fed back to the + unregulated node of the main board by CR2. This voltage is in parallel with any unregulated voltage that may be supplied by the transformer on the main board.

Z2, C4, and R6 form a free running oscillator and driver for Q1 and Q2 at about 5kHz. Q1 and Q2 provide a "charge pump" effect to generate the lower current—unregulated supply through CR5, CR6, CR7, C5, C6, and C7. This voltage is decoupled from the main board with CR3.

Front panel input on the 406 and 407 are wired internally to the rear input terminals on the main board. For thermocouple units, appropriate thermocouple extension wire is used for this purpose to maintain reference junction integrity to the front binding posts.

The Model 407 contains additional circuitry for calibration output. 10-turn wirewound pot R10 provides a stable "coarse" adjust. R10 is biased correctly by R8, R9, and R11. R13 injects offset current to R10 via pot R12, thus providing a fine adjustment. R12 is a single-turn composition unit ganged with a two-pole switch SW2. With R12/SW2 in the most counterclockwise position, SW2 pins 1 and 2 are open, disconnecting the calibrator output from both the instrument and the front panel terminals. The unit is used as a conventional indicator in this mode. SW2 pins 3 and 4 effectively short the calibrator, preventing interactive ground currents from flowing. Z1 pins 10, 9, 8 provide high impedance referencing of the pot circuit to ground, Z1 pins 2, 3, 1 provide a buffered output and drive the output divider R14 and R15. Z1 pins 5, 6, 7 and R16, R18, and R17 generate an opposing current to the output divider and prevent offset from occurring in return wires to the instrument.

Switch Error (Option 001A)

The Switch Error board detects simultaneous pushbutton selection from any two rows. When a switch error occurs, the display is blanked. This is accomplished by sensing the resistance within the switching matrix.

If two or more pushbuttons are selected, the 100k Ω resistor from each switch becomes in parallel, causing a net resistance of 50k Ω or less. The Switch Error board senses this resistance as an input to transistor Q2. The base of transistor Q2 is biased on with 50k Ω or less, which in turn, turns on Q1. When Q1 conducts, +7.2 volts is applied to the reset input of the LSI chip (pin 33) causing the instrument to halt display strobing, which blanks the display.

BCD Data Output (Option 002A)

Option 002A provides fully isolated parallel digital outputs which are TTL compatible. The LSI device (Z9) on the main 400A board generates a serial BCD output on pin 32. This data is in a pulse width modulated format and includes polarity and overload information. The data enters the 002A board through J1 pins and is level shifted and amplified by R3, R4, and Q3. Opto isolator Z1 is driven by Q3 and provides isolation of data. The receiving side of Z1 is shaped and buffered by R10 and Z3 (7, 6). The pulse width modulated data (6 4-bit words) is inverted by Z3 (14, 15) and presented to the input to a 24-bit shift register comprised of Z6, Z7, and Z8.

Clocking information for the shift register is provided by pin 7 of one-shot Z4. One shot time is adjusted for ~9 μ s which is halfway between a "1" and a "0" pulse width. Thus, a "1" or "0" is clocked into the shift register for each data pulse.

The second half of one-shot Z4 (pin 10) provides a 3.5msec pulse triggered off the first data bit. This pulse is slightly wider than the entire 24-bit shift sequence and disables the data valid (DAV) output flag until data shifting has been completed. When DAV goes true (high) all parallel digit outputs are stable and can be read correctly by an external printer or peripheral.

Command control of the data is handled with two lines. HOLD sets the R-S flipflop comprised of Z5 (1, 2, 3) and Z5 (11, 12, 13). This flipflop is reset at every update period unless the HOLD line is held low. When the flipflop is set, A5 is “on” and Opto Z2 is also on. FET Z4 also turns on and forces pin 35 of Z9 on the main board high, or in a continuous hold position. When HOLD is released, the main board one-shot of Q7, R40, and C20 functions normally and begins a new encoding.

The data request (DAR) line requests a positive edge to initial BCD data updating. This edge is detected by Z13 (3) and latched by Z13 (9). Z13 is reset with the 3.5msec pulse from Z4 (10) after every ready. To eliminate the necessity for continuous positive edges on the DAR if continuously updated output is desired, the continuous output pin (COP) is provided. If this line is switched to DAR, BCD output updates automatically with each encoding.

The power supply for the 002A option is derived from the main board 400kHz clock. This square wave is buffered by Q1 and Q2 and isolated with C2, R2, and T1. The signal is rectified and filtered on T1's secondary by CR2, CR3, CR4, CR5, and C5. Zener CR6 regulates the output to provide a TTL compatible supply and logic reference.

Alarm Setpoint (Option 003A/004A)

J1 is the interconnect to P2 on the Model 400A/410A main board and is paralleled with P1 to facilitate “daisy chaining” of additional options. Pin 5 of J1, serial data out from the 400A/410A, is converted to parallel BCD data by Z1, Z4, Z5, and Z6. This parallel data (sign and magnitude) are applied to side A of BCD adder string Z7, Z8, Z9, and Z10. The least significant digit (LSD) of Side B of the adder is connected to Z19. A quad nor gate, Z19 acts like a multiplex gate, adding the BCD value of S3 (0 - 9) when appropriate (see Figure 3).

The output of the BCD adder (Z7, Z8, Z9, Z10) connects to Side A of the comparator chain (Z11, Z12, Z13 and Z14). Side B is connected to a second BCD adder (Z15, Z16, Z17 and Z18). Side A input to the adder is connected to switch module S1 and S2-A through S2-D, which are used to enter the desired setpoint. The B input to adder (Z15, Z16, Z17 and Z18) has the LSD connected to the output of Z20. Z20 works the same way as Z19 and applies a 0 - 9 from S3 (hysteresis switch) when logic conditions are satisfied (see Figure 3).

Z3, Z21 and Z22 provide a logic “1” at Z23 (pin 5) according to Figure 3. The clock input of Z23 is supplied by the delay one-shot (Z1 pin 9), allowing serial data to settle before updating Z23 (pin 1) is the “setpoint true” signal that drives Z23 (pin 8) and Q1, Q2. These transistors, in turn, actuate K1 and illuminate CR2, indicated setpoint true.

In automatic reset position of S4, Z23 (pin 10) is connected to Z23 (pin 2, $\overline{Q}$) and is automatically returned to zero (Q1 and Q2 off) when the next “not out-of-limit” condition exists.

In manual mode, reset is accomplished by shorting across “remote reset” terminals. This short causes the 400kHz clock (impressed on primary of T2) to be coupled across the guard to T1 and back to the reset pin of Z23 (pin 10). In the manual mode, reset is accomplished only by remote or local actuation after process variable has returned within limits.

HI/LO	POLARITY SETTING	ALGEBRAIC 400A/410A READING*	ALARM Z23-5
HI	+	- or + <	0
HI	+	+ >	1
LO	+	+ >	0
LO	+	- or + <	1
HI	-	- <	0
HI	-	+ or - >	1
LO	-	+ or - >	0
LO	-	- <	1
* relative to setpoint			
EXAMPLE: If the HI/LO limit on the thumbwheel switch is set on “HI” and the numerical polarity setting is plus, a 400A/410A reading of any plus value greater than the thumbwheel setting places a logic “1” at pin 5 of IC Z23.			

Figure 3. Truth Table

Analog (Option 005A)

J1 is the interconnect to P2 on the Model 400A/410A main board and is paralleled with P1 to facilitate “daisy chaining” of additional options. Pin 1 of J1, feeds a 400kHz clock signal to the inputs of three stages of hex CMOS inverter Z1. These outputs are paralleled and connected to the primary of T1 and to the inputs of the other 3 stages of Z1. The outputs of these three stages are paralleled and connected to the other side of T1 primary. This produces a 22V square wave at the secondary. Spikes are filtered by C3. Diodes CR1 through CR4 form a full-wave bridge. C4 and C5 provide a filtered $\pm 10V$ to power the analog and digital circuitry.

Transistor Q1, IC Z2, and associated components provide isolation for the coded serial BCD data from the 400A/410A. Z3 inverts and buffers the data, routing it to Z4 and Z8. Z6, Z7 and Z8 are 8-bit serial to parallel shift registers with integral output latches. The serial data is applied on pin 2 of Z8. A shift-clock generated by pin 7 to Z4 is applied to pin 3 of Z6, Z7, and Z8. The output latch strobe is formed by pin 9 of Z4 and is used to update the data after all six decades have been shifted into the serial-to-parallel register.

Parallel BCD data are applied to comparators Z11 through Z14. The other side of these comparators is connected to the BCD counters Z15 through Z18. These counter form divide-by-4000 timing information which is compared with BCD data. The “greater than” (A>B) output Z11 (pin 13) provides a pulse output with a 100Hz repetition rate. This pulse width is proportional to the magnitude of the BCD data (see Figure 4). This pulse is applied to the quad-analog switch (see Figure 5) via Z3 and Z9 to provide drive phase.

Z5 and associated components provide a $\pm 6.4\text{VDC}$ reference. The appropriate polarity reference is applied through R15 or R16 and span adjust pots R13 or R14. Z19 and associated components provide output buffering and filtering to give smooth DC out.

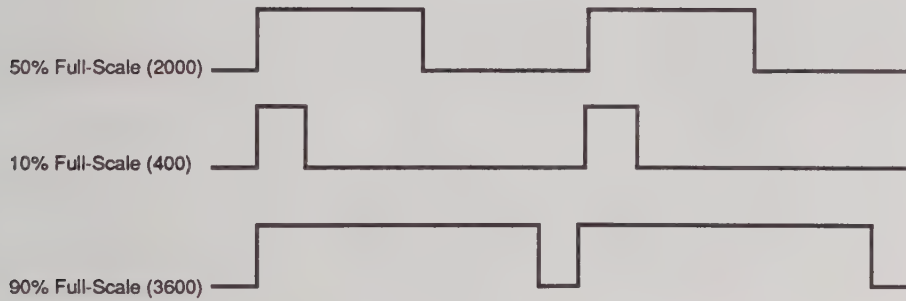


Figure 4. Pulse Width/BCD Data Magnitude

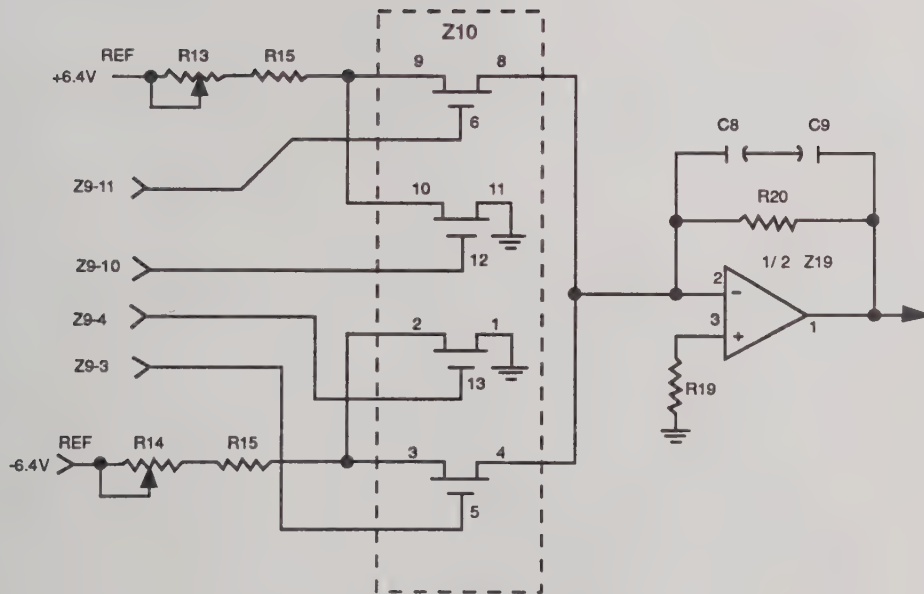


Figure 5. Quad-Analog Switch (Z10)

Test Equipment

- Thermocouples: a DC calibrator capable of supplying voltages up to 100mV with better than one microvolt resolution is required. A stable ice bath, accurate to 0.05°F, is also needed.
- K1, K2, K3, K4, K5 Ranges: a DC calibrator (see item a above) is required, except an output of up to 25V is necessary (K4 range).
- I₁, I₂, I₃ Ranges: a current calibrator with 1μA resolution from 4 to 50mA is required.
- RTD Ranges: 000.00 to 400.00Ω calibration pot with 0.01Ω resolution is required.
- TH Ranges: 1000.0 to 30,000.0Ω calibration pot with 1.0Ω resolution is required.

Calibration Procedure

In all cases, allow instrument to warm up for 30 minutes before calibrating.

Thermocouples

- Prepare test wires for ice bath as shown in Figure 6.
- Connect the DC calibrator and ice bath to the instrument as shown in the setup diagram in Figure 7.
- Refer to calibration chart in Figure 8 and perform calibration.

EXAMPLE: For Type K thermocouple. Connect the DC calibrator to instrument +V and -V. Apply 0.000mV and adjust Front Panel Zero (R44) to give a display of 32°F or 0°C. Apply 54.845mV and adjust + Span (R45) to give a display of 2500°F. R44 and R45 are visible at the upper left of the display with the front panel plexiglass removed.

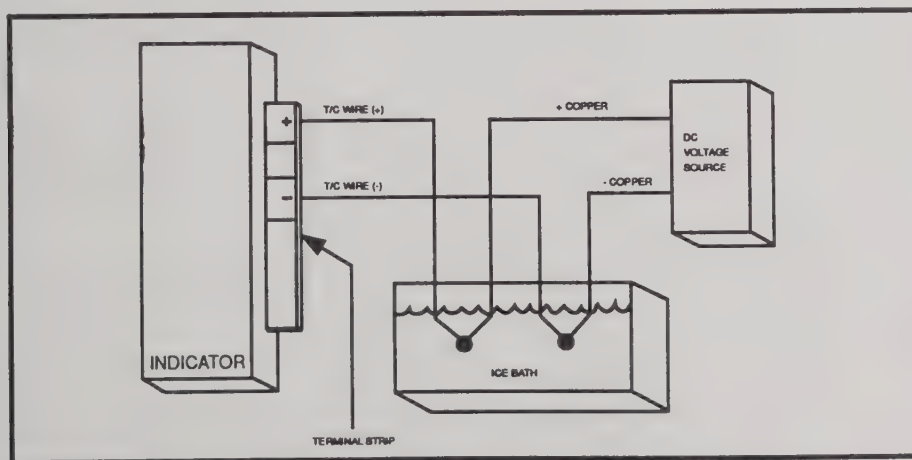


Figure 6. Calibration Setup

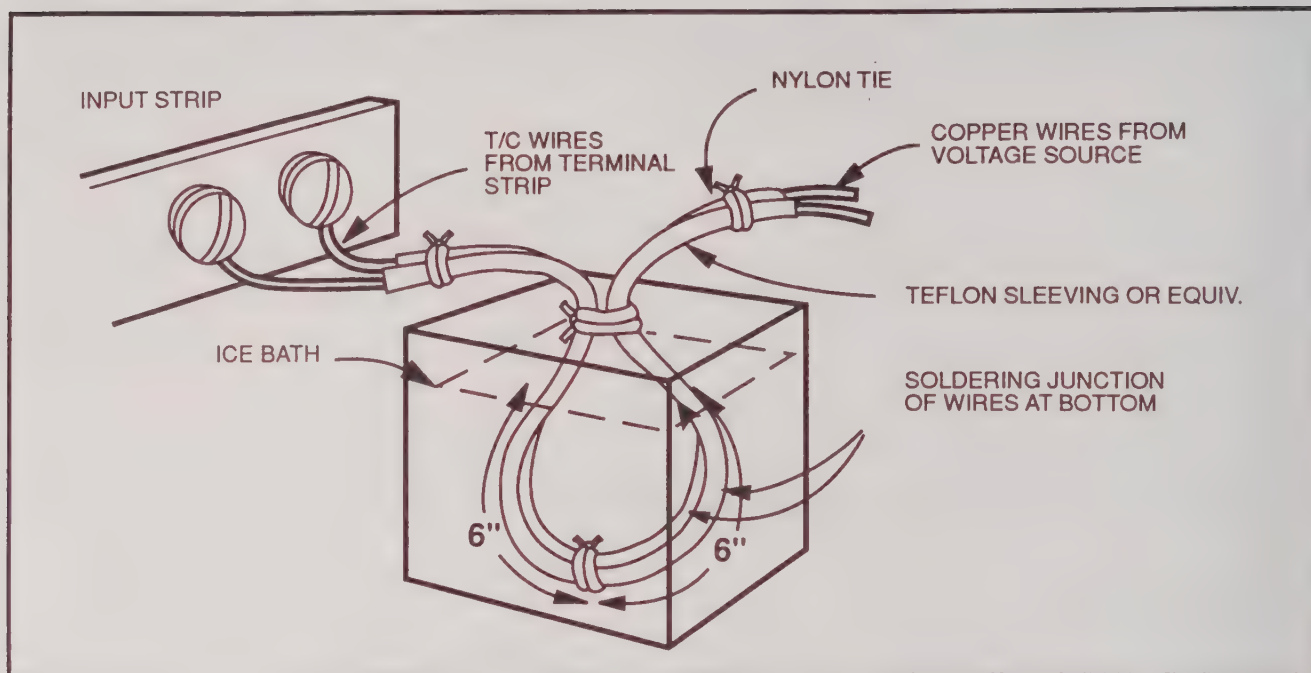


Figure 7. Preparing Wires for Ice Bath

Note

The B thermocouple output below 912°F (488°C) is only 1.3 $\mu\text{V}/^\circ\text{F}$ (2.4 $\mu\text{V}/^\circ\text{C}$). While the instrument linearity is excellent above 912°F, the "B" μV table will better approximate lower temperatures.

Linear Voltage Ranges

K1, K2, K3, and K4 Ranges

Calibration consists of two mandatory pot adjustments, ZERO and +SPAN. These adjustments are located on the upper left behind the plexiglass front panel (extract two front panel screws). The pots are labeled with their respective function on the PC board.

If required, -SPAN can also be adjusted (R14). This pot is located at the rear of the instrument between the input terminal strip and P2. For all applicable ranges, -SPAN display readings should be verified with the appropriate input voltage per the calibration chart and the -SPAN pot (R14) adjust if necessary.

- Connect the DC calibrator to the +V and -V terminals of the instrument.
- Perform calibration per the calibration chart, inputting the appropriate voltage and adjusting the appropriate pot for the desired display reading. Calibration must be performed in the following sequence, (a) Zero, (b) +SPAN, and (c) -SPAN (if necessary).

K5 Range

- Connect the voltage calibrator to the +V and -V terminals (rear panel) of the instrument.
- Apply 0V and adjust the OFFSET pot, located on the analog programming module, to the desired minimum reading. If necessary, the ZERO pot located behind the plexiglass front panel (extract two front panel screws) can be used to fine tune this adjustment.

- c. Apply +5V and adjust the three span pots as required for the maximum desired reading. The three pots in order of degree of refinement are the C (coarse) pot and FINE pot (both located on the analog programming module), and the +SPAN pot located behind the plexiglass front panel.
- d. Reapply 0V input and recheck the display reading. If required, repeat steps b and c above.

Current Transmitter Ranges

I1 and I2 Ranges

Calibration consists of two pot adjustments, ZERO and +SPAN. These adjustments are located on the upper left behind the plexiglass front panel (extract two front panel screws). The pots are labeled with their respective function in the PC board.

- a. Connect the current calibrator to the +I and -I terminals of the instrument.
- b. Perform calibration per the calibration chart, inputting the appropriate current and adjusting the appropriate pot for the desired display reading. The ZERO adjustment should be performed first and the +SPAN adjustment performed next.

I3 Range

- a. Connect the current calibrator to the +I and -I terminals of the instrument.
- b. Apply 4mA and adjust the OFFSET pot, located on the analog programming module, to the desired minimum reading. If necessary, the ZERO pot located behind the plexiglass front panel (extract two front panel screws) can be used to fine tune this adjustment.
- c. Apply 20mA and adjust the three span pots as required for the maximum desired reading. The three pots in order of degree of refinement are the C (coarse) pot and FINE pot (both located on the analog programming module), and the +SPAN pot located behind the plexiglass front panel.
- d. Reapply 4mA and recheck the display reading. If required, repeat steps b and c above.

RANGE	SENSOR TYPE	INPUT	ADJUST	READ	INPUT	ADJUST [†]	READ	INPUT	READ
J, 2J	Iron-Constantan	0mV 0mV	Zero Zero	32°F 0°C	39.407 42.283	Span Span	1300°F 750°C	-7.519 -7.659	-300°F -190°C
K	Chromel-Alumel	0mV 0mV	Zero Zero	32°F 0°C	54.845 52.398	Span Span	2500°F 1300°C	-4.381 -3.553	-200°F -100°C
T, 2T	Copper - Constantan	0mV 0mV	Zero Zero	32°F 0°F	20.801 20.252	Span Span	750°F 390°C	-5.341 -5.439	-300°F -190°C
R	Platinum – Platinum 13% Rhodium	0mV 0mV	Zero Zero	32°F 0°C	19.518 20.878	Span Span	3000°F 1750°C	– –	– –
S	Platinum – Platinum 10% Rhodium	0mV 0mV	Zero Zero	32°F 0°C	17.347 18.504	Span Span	3000°F 1750°C	– –	– –
B	Platinum 30% Rhodium Platinum – 6% Rhodium	0mV	Zero	32°F	13.763	Span	3300°F	–	–
		0mV	Zero	0°C	13.585	Span	1800°C	–	–
FC	Iron-Constantan (DIN)	0mV 0mV	Zero Zero	32°F 0.0°C	53.064mV 50.320mV	Span Span	1650.0°F 860.0°C	-8.022mV -8.006mV	-320.0°F -195.0°C
CC	Copper- Constantan (DIN)	0mV 0mV	Zero Zero	32.0°F 0.0°C	31.492mV 33.954mV	Span Span	1040.0°F 595.0°C	-5.405mV -5.510mV	-300.0°F -190.0°C
E	Chromel- Constantan	0mV 0mV	Zero Zero	32.0°F 0.0°C	81.273mV 76.357mV	Span Span	1950.0°F 1000.0°C	-8.768mV -8.273mV	-324.0°F -180.0°C
P3, P4	Platinum 100Ω RTD (DIN)	100.00Ω 100.00Ω	Zero Zero	32.0°F 0.0°C	390.38Ω 390.38Ω	Span Span	1562.0°F 850.0°C	– 18.53Ω	-328.0°F -200.0°C
P5, P6	Platinum 100Ω RTD (USA)	100.00Ω 100.00Ω	Zero Zero	32.0°F 0.0°C	381.19Ω 381.19Ω	+Span +Span	1472.0°F 800.0°C	17.02Ω 17.02Ω	-328.0°F -200.0°C
C3, C4	Copper RTD	9.04	Zero	32°F	16.91	+Span	400.0°F	–	–
		6.73	-Span	-76°F					
		9.04	Zero	0°C	16.74	+Span	200.0°C		
		6.73	-Span	-60°C					
TH	F/C Switch	Thermistor	T1-100K	Zero	32°F	T1-100K	+Span	212°F	–
TC	in °F* Position	Thermistor	T1-100K	Zero	0°C	T1-100K	+Span	100°C	–
			T2-25.425K			T2-1.602K			–
I ₁	4-20mA Transmitter	4.000mA	Zero	-0.00%	20.000mA	Span	100.00%	–	–
I ₂	10-50mA Transmitter	10.000mA	Zero	-0.00%	50.000mA	Span	100.00%	–	–
I ₃	4-20mA Transmitter	4.000mA	Offset*		20.000mA	C & Fine Span*		–	–
K1	-10mV to +25mV Linear	0mv	Zero	-0.000mV	25.000mV	Span	25.000mV	-10.000mV	-10.000mV
K2	-100mV to +250mV Linear	0mV	Zero	-0.00mV	250.00mV	Span	250.00mV	-100.00mV	-100.00mV
K3	-1V to +2.5V Linear	0mV	Zero	-0.0000mV	2.5000mV	Span	2.5000mV	-1.0000 V	-1.0000V
1000mV (408, 418)	-0.5V to + 1.0V Linear	0mV	Zero	-0.0mV	1.0000V	Span	1000.0mV	-500.0mV	-500.0mV
K4	-10V to + 25V	0mV	Zero	-0.000V	25.000V	Span	25.000V	-10.000V	-10.000V
K5	0-5V	0mV	Offset*		5.000V	C & Fine Span*		–	–

* Refer to text

+ Although minus span adjust is normally not required, R14 may be adjusted.

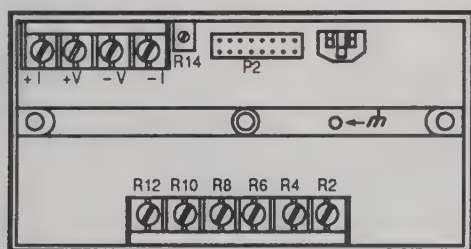
Figure 8. Calibration Chart

RTD and TH Ranges

Refer to calibration chart and perform calibration.

Multi-range Units

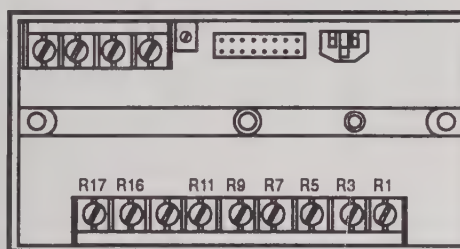
The following charts list calibration adjustments for multi-range instruments. Complete and accurate calibration for all ranges requires that the instrument be returned to the factory. Touch-up span calibration can be achieved by adjusting the appropriate span pot accessible from the rear. On these units, the zero pot (behind the front panel) may be adjusted for a particular range at the expense of remaining ranges being slightly off at zero (ice point). It may be necessary to readjust ice point for the particular type thermocouple being used (particularly common with types R, S, and B). Always adjust ice point before adjusting full-scale. Minus span pot R14 may be adjusted if desired for a particular range, but is common for all ranges. Input and nominal calibration values are the same as shown in the calibration chart in this section.



TC TYPE	ICE POINT ADJUST	FULL-SCALE ADJUST
B	Zero*	R12
J	Zero*	R2
K	Zero*	R4
T	Zero*	R6
R	Zero*	R8
S	Zero*	R10

*Zero adjust is on front panel

MODELS 403, 415



PT-100 REF PT-100 E CuCon K FeCon
1000mV JCT (TC) 1000mV
OFFSET CONTROLS SPAN CONTROLS

RANGE TYPE	ZERO ADJUST	FULL-SCALE ADJUST
FeCon	Zero*	R1
K	Zero*	R3
CuCon	Zero*	R5
E	Zero*	R7
PT3, PT4	PT R17	R11
1000mV	mV R16	R9

*Zero adjust is on front panel

MODELS 408, 418

Power Pack 406 and 407

- Connect front panel inputs the same as indicator rear inputs.
- Adjust according to calibration chart. Model 407 potentiometer switch must be OFF.
- Models 406 and 407 may be calibrated while line charging or running on batteries.

Analog Output

The Analog Output board is provided with three pots for calibration. See Figure 9. Use the calibration setup shown in Figure 6 to calibrate the Analog Output board. Connect a known source to the indicator from which the Analog Output board is converting. Connect a DVM with 100 μ V resolution to the output terminals of the Analog Output board. Adjust R18 (zero), R14 (+ full-scale), and R13 (– full-scale) with the appropriate input in that order until the millivolt output agrees with the indicator display in the following fashion:

Analog Output = display counts x 1mV. (This applies to degrees, but not to tenths of degrees.)

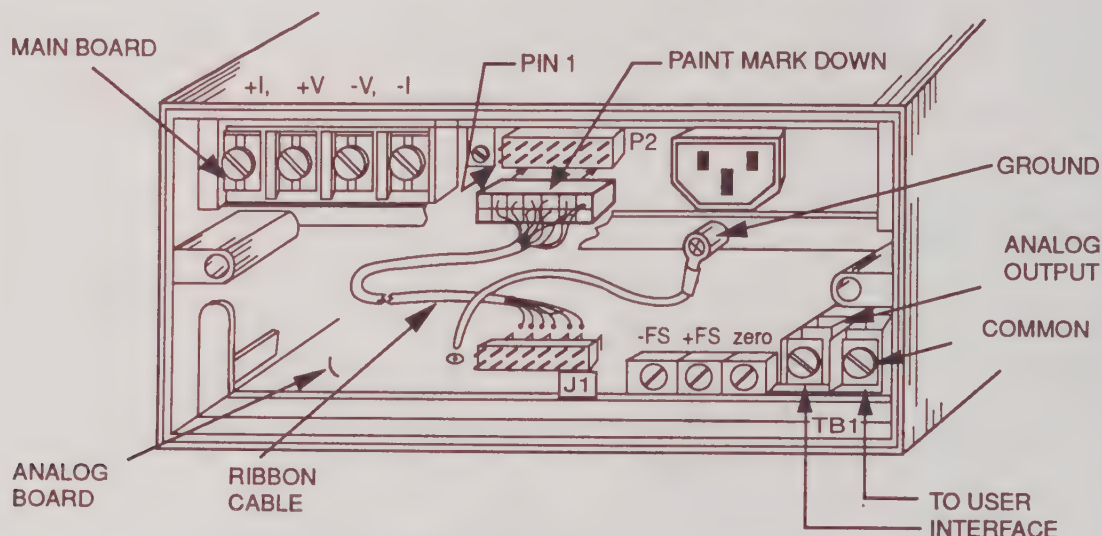


Figure 9. Rear View, Option 005A Calibration Pots

400A Series Main Board Test and Calibration

Power Supply Adjustment

Connect DVM LO lead to right side of R20 (ground) and HI lead to case of Q2. Adjust R13 to -7.2V.

Clock Adjustment

Connect frequency counter to right side of R20 (ground) and pin 17 of display strap. Adjust R38 to 317Hz.

Preamp Offset Adjustment

Connect a jumper lead from test 7.2V (case of Q1) to rear connector terminals P2 pin 2 (display blank). Connect DVM LO lead to right side of R20 (ground) and HI lead to left side of R23 (56.25k). Adjust R22 of 0 $\pm$ 10mV on DVM 1V range.

Auto-Zero Adjustment

Leave the jumper connected. Move the DVM HI lead to left side of R34 (100k Ω). Adjust R29 for 0 + 200mV. Remove jumper and proceed to next step.

Zero Gap Adjustment (for 410A only)

Adjust R28 counterclockwise fully to the end.

Zero Adjustment (short input only—won't work with thermocouple)

Connect a jumper lead from -7.2V (case of Q2) to left side of R16. Adjust R19 for 32.0 or 0.0 on front panel display. Leave jumper connected and proceed to next step.

Full-Scale Adjustment (input to -V, +V)

Connect calibrator LO to lead to right side of R20 and HI lead to high end of R15 (10k Ω 2W). Refer to calibration table for the correct mV inputs per thermocouple range. Adjust calibrator to full-scale inputs. Adjust span R45 for + full-scale reading on the display. Adjust R14 (next to rear input terminals) for - full-scale display. *Remove jumper on Q2 to R16.*

Seal pots R19, R22, R28, R29.

Thermocouple/Reference Adjustment

Thermocouple leads to input. Submerge thermocouple in an ice bath. Adjust zero pot R44 for a reading of 32.0 on display.

Quick 400A and 410A Fixes

O.L. = Overload

TA = Ambient Temp.

F/S = Full-Scale

CV = Correction Voltage

PS = Power Supply

RJ = Reference Junction

Problems	Causes
1. 30-0-32	Q8
2. $\pm$ F/S & ZERO OK	TA low
3. All "A" segments intermittent on	Metal under S-2
4. Leading zero's cause by P.S.	Z4
5. Noisy, shorting Z2 out to ground caused noise to stop	Z2
6. Low zero, low $\pm$ F/S	Z4
7. Incorrect readings, display DIM	Z9
8. DS1 always on	Z10
9. Leading zero's	Z10
10. -F/S noisy	Z5
11. Z5 locked, output approx. 6V	Z5
12. High, sometimes locks open on $\pm$ F/S, OK on -F/S & Zero	Z3
13. P.S. "0" V, Q1 hot	R44 shorted
14. R.J. at 32°F	Z3
15. Locks, C.V. at Z2 won't null	Z1
16. Locks, C.V. OK	Q7
17. No display, only dec. point lights	Z10
18. Flashes to zero	C22
19. Skips 31°F	Z6
20. $\pm$ F/S low and noisy	C15
21. Skips 32°F	Z6
22. Fast sample rate	Check Q7, C20, R40
23. High zero	Z8
24. Low and noisy on R,S scale	C15

400A/410A General Troubleshooting Procedure

To fix a 400A/410A, first check the supplies. If the supplies are bad and there is no unreg. voltage, check the two 10Ω resistors on the AC input for burns. Check the transformer, and C4, C5, and C6, especially if they are puffy or dented. Ohm the rectifier while the transformer is pulled. Be careful of the plated through hole on the + side of C4. If you have unregulated voltage, then check/replace Z8, Q1, and Q2 (if the zener is OK). For low level noise try C7 and C8.

Next swap out the LSI chip and the 24-pin module in the back to see if they're OK. Make sure that the LSI chip is the right number (7500 or 7501) for the range being used. If the unit is still bad, replace Z1, Z3, and Z7. Since Z1, Z3, and Z7 are quad chips and are spread out in the analog section, checking these may resolve many problems.

If the display is missing segments, it is probably the display that's bad. If all the displays are missing the same segment, then it's probably one of Q9 through Q15 since the displays are scanned. If one display is missing or won't go out, then it's probably Z10. If there is no display at all, then the clock is probably missing. Replace Z7. If there are too many zeros and/or decimal points, check the settings on switch S2. If there is no zero at zero and S2 is set right, then check Q8, Q16, the 100Ω on Z11, and the dip switch.

Sometimes the unit locks on one number and stays there no matter what the input is. Replace Q7 and C20. The "B" range does this normally and can be reset only by removing AC from the Unit.

Noise and Drift Problems

First check the supplies for noise. Then make sure that the 24-pin socket is gold plated and the contacts are in good condition. If not, replace it. Soldering the component leads that connect to etch on the top of the board is also effective, especially for motion related noise. If you put the unit in auto-zero and look at the outputs of the op-amps, you can sometimes find the noisy chip. Next ground the output of Z2 (pin 6 or the left side of R23). If the noise goes away, then it's probably Z2, Q3, Q4, Q5, C9, C10, and C11. Check them all. If it's still there, check Z1, Z3, Z4, Z5, Q6, and Z7. Then C14, C15, and R29. Shotgunning noise can be cheaper and save time (depending on how fast you can change chips). Also try the LSI socket, since these too can cause noise. Green pots also cause noise, especially if its R29.

If the Unit Reads the Wrong Number

- Check the supplies for about 7.18V.
- Check that the correct module and LSI are being used for the thermocouple desired.
- Check the internal calibration using the 400A test procedure.
- If the unit still reads wrong, leave the input jumpered. Hook a jumper from the left side of R23 to the right side of R20. The reading should remain the same. If it changes to the ambient temperature, then check Z2, Z1, C9, 10, 11, Q4, and Q5.
- If the reading stays the same, hook another jumper from the tab of Q1 to the left side of R16. The unit should read 32° in F° or 0° in C° since the reference junction is now disabled and the preamp is grounded to zero from step d. If the 32° or 0° appears when this is done, then the reference junction circuit is bad. Replace Q3 and Z3.
- If the reading is still wrong, then the auto-zero circuit is suspect. Replace Q6, C14, and Z3.
- If it is still bad, check Z1, Z3, Z4, Z5, Z6, and Z7.

Display Dead (reads nothing)

- a. Check the supplies for 7.18V.
- b. Check that pin 13 of Z7 has a 400kHz clock coming out of it. If not replace Z7.
- c. If the clock is present, swap out the LSI. If it works, then the LSI was bad.
- d. If the display still doesn't light, replace Z10.
- e. If it still doesn't light, then a display may be shorted. Remove them one at a time until it works. Replace that display.

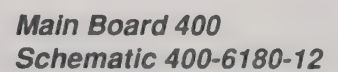
Display Missing Segments

- a. If the same segment is missing in every display, then the driver transistor for that segment or the resistor in Z11 is bad. Sort Q9-Q15 collector to emitter one at a time until the missing segments light. Replace this transistor. If none light, jumper over the resistors in Z11 one at a time until the segments light. If they do, replace Z11.
- b. If an entire display won't light or won't go out, check that the ribbon cable isn't broken. Then replace Z10. If the display still doesn't light, then replace the display and Z10 together.
- c. If random segments are lighted, then the LSI is bad or the unit is not resetting on power up. Swap out the LSI. If it's still bad, then replace Q7 and C20 and check that the board is not dirty.

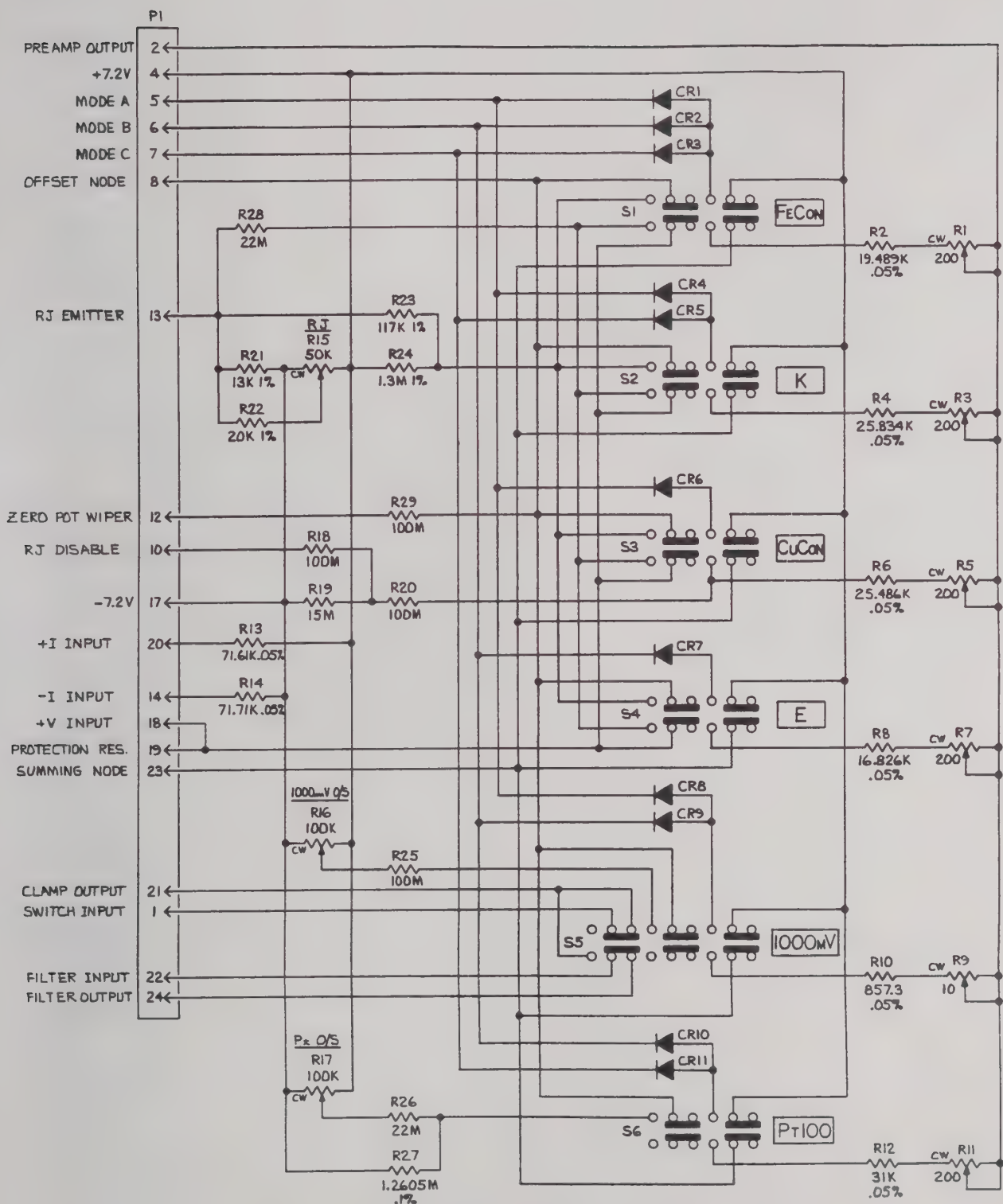
Miscellaneous Display Problems

- a. If the unit will not display a zero for a zero reading but otherwise is normal, check that a decimal switch is selected (S2). Even if no decimal is desired, one switch must be selected. If this is OK, then replace Q8 and Q16.
- b. If the leading zeroes won't suppress (reads 0032.0) *at ice point* regardless of how S2 (the decimal switch) is set, replace Q8 and Q16.
- c. If the decimal point won't light, check the setting on S2. One switch must be selected (but not two). If no decimal can be made to light by throwing the decimal switches (S2 1-5), then the resistor in Z11 that drives this is bad. Replace it. If others are OK, replace that display.
- d. If the unit will only read °C or °F even when the C/F switch is switched, put a volt meter from ground to pin 5 of the LSI (Z9). Check that it switches from 0V to 7.18V as the C/F switched (S2 #6). If it is, then replace the LSI. If not, check that the ribbon cable coming from S2 is OK. If it is, replace S2.

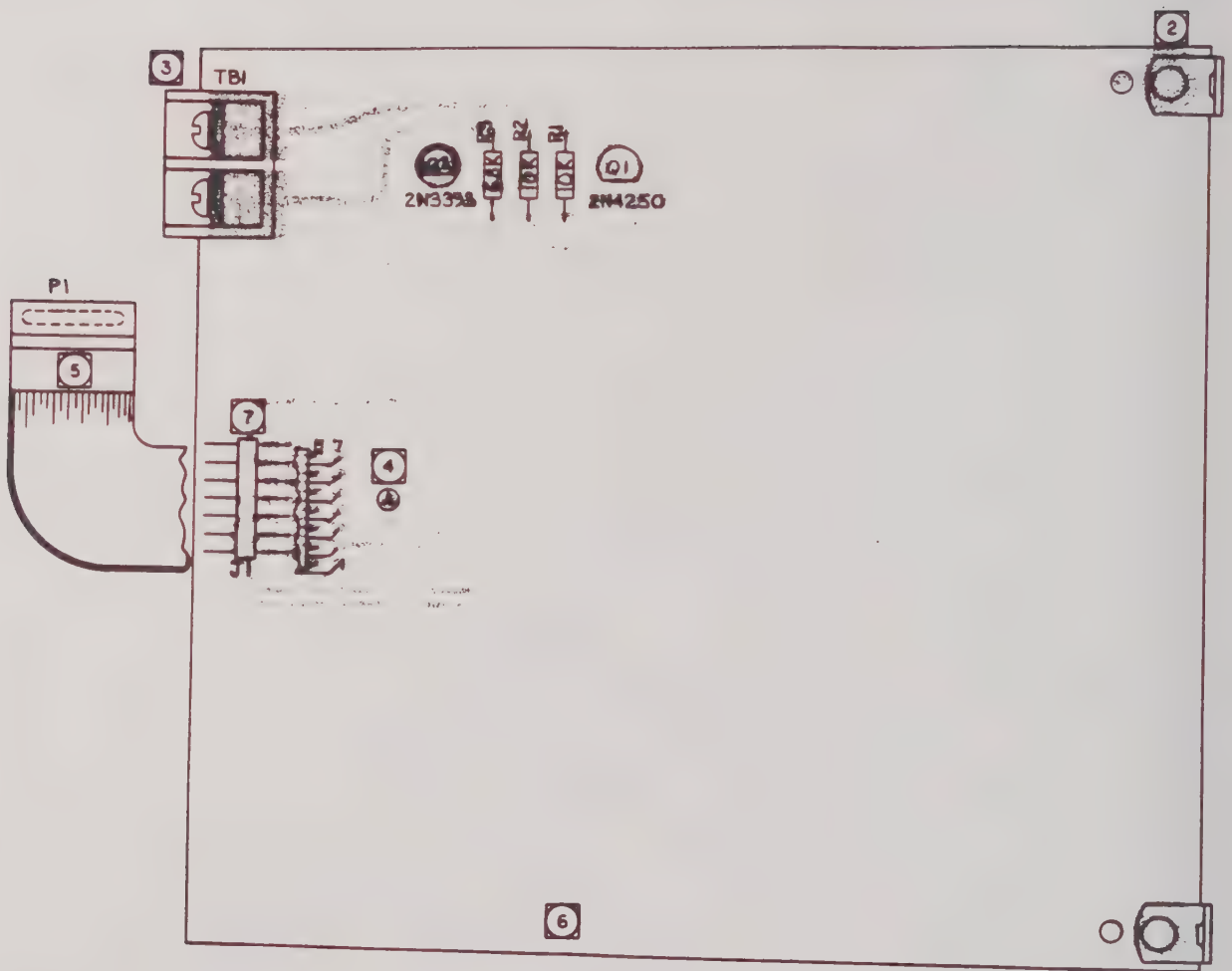
DRAWING	TITLE	TYPE* DRAWING	PAGE
400-4180-XX	Main Board, Model 400A	A	22
400-6180-XX	Main Board, Model 400A	S	23
400-4190-XX	Main Board, Model 410A	A	24
400-6190-XX	Main Board, Model 410A	S	25
400-4130-XX	DIN Multi-range Board	A	26
400-6130-XX	DIN Multi-range Board	S	27
400-4420-XX	Switch Error Indicator Board	A	28
400-6420-XX	Switch Error Indicator Board	S	29
400-4431-XX	Current Loop	A	30
400-6431-XX	Current Loop	S	31
400-4440-XX	BCD Data Board	A	32
400-6440-XX	BCD Data Board	S	33
400-4450-XX	Multi-range Board	A	34
400-6450-XX	Multi-range Board	S	35
400-4580-XX	External Switching Unit	A	36
400-6580-XX	External Switching Unit	S	37
406-4200-XX	Power Pack, Model 406	A	38
406-6200-XX	Power Pack, Model 406	S	39
407-4110-XX	Power Pack Pot., Model 407	A	40
407-6110-XX	Power Pack Pot., Model 407	S	41
409-4100-XX	RTD Switching Unit	A	42
409-6100-XX	RTD Switching Unit	S	43
000-7840-XX	Dimensional Outline	O	44
400-440X-XX	Setpoint Board	A	45
400-6400-XX	Setpoint Board	S	46
400-4410-XX	Analog Output Board	A	47
400-6410-XX	Analog Output Board	S	48
411-400X-XX	Model 411A	A	49
*A = Assembly	S = Schematic	O = Outline	



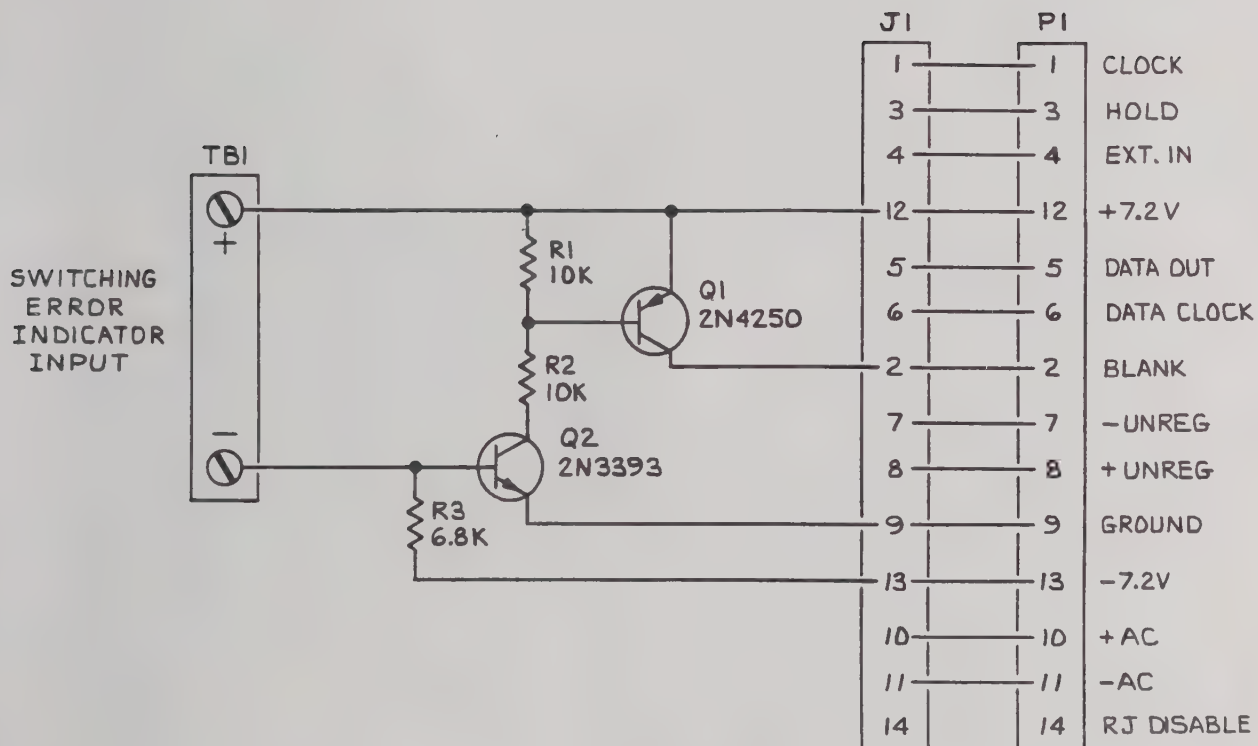




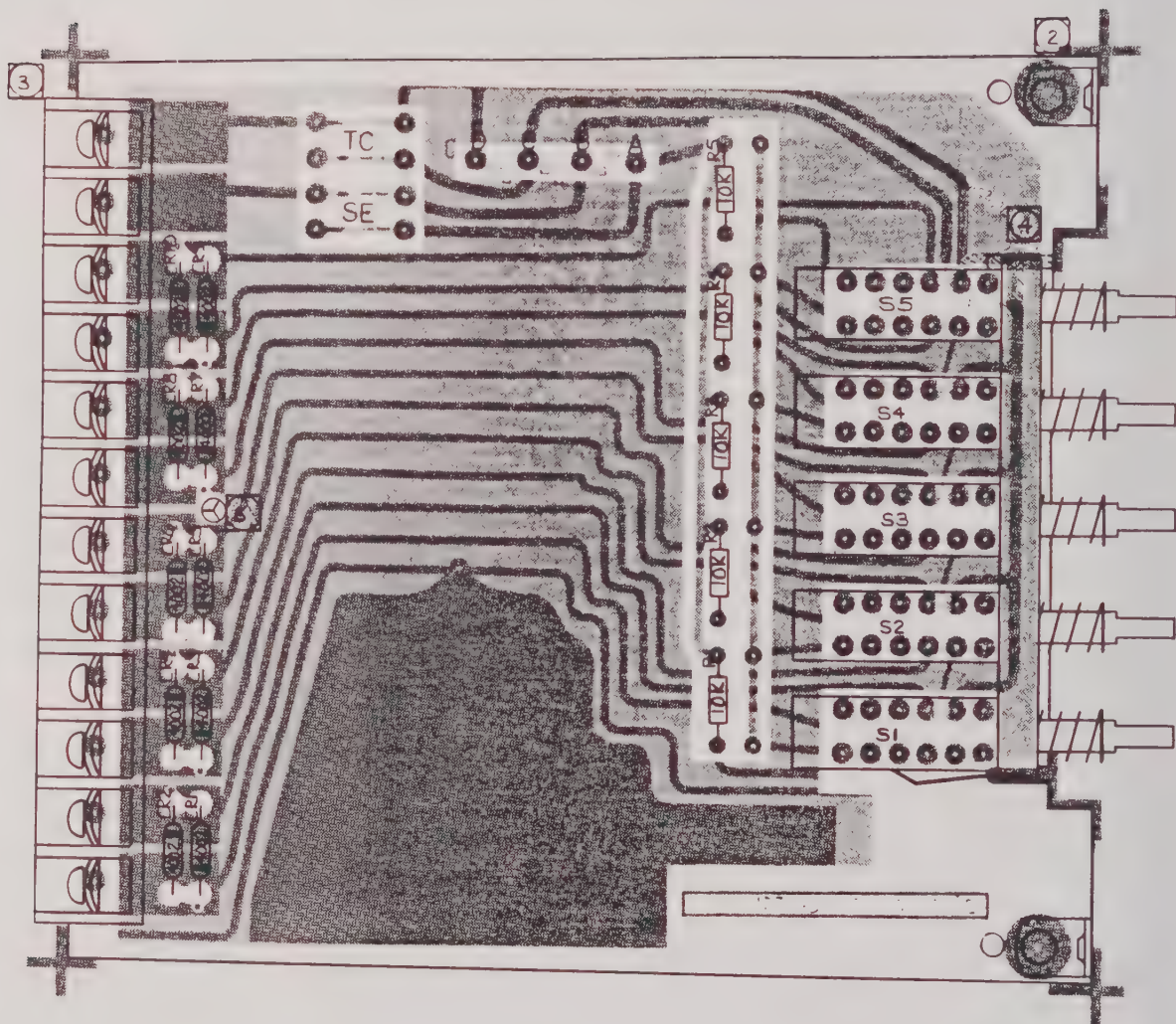
**DIN Multi-range Board
Schematic 400-6130-00**



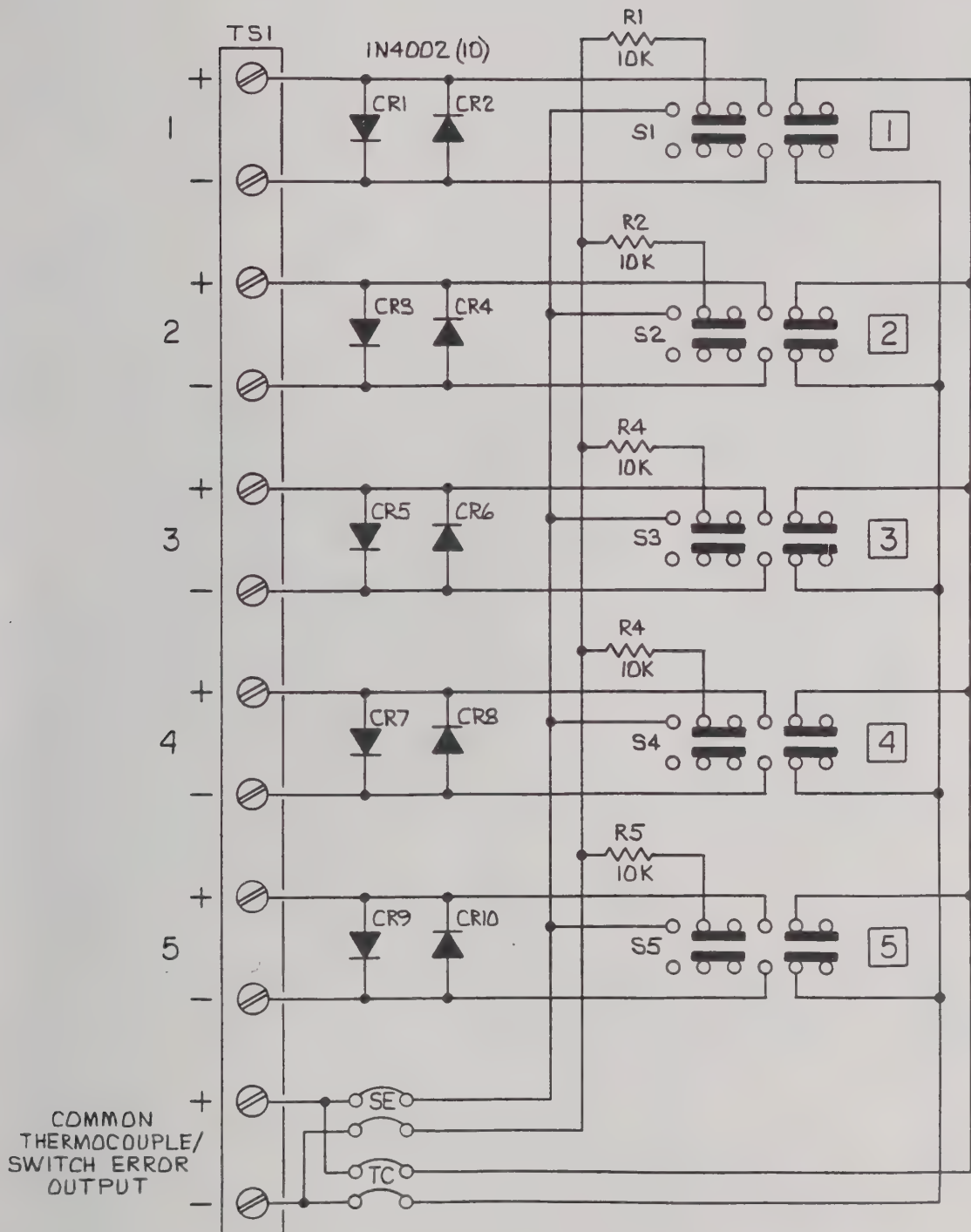
**Assembly Switch
Error Indicator
400-4420-01B**



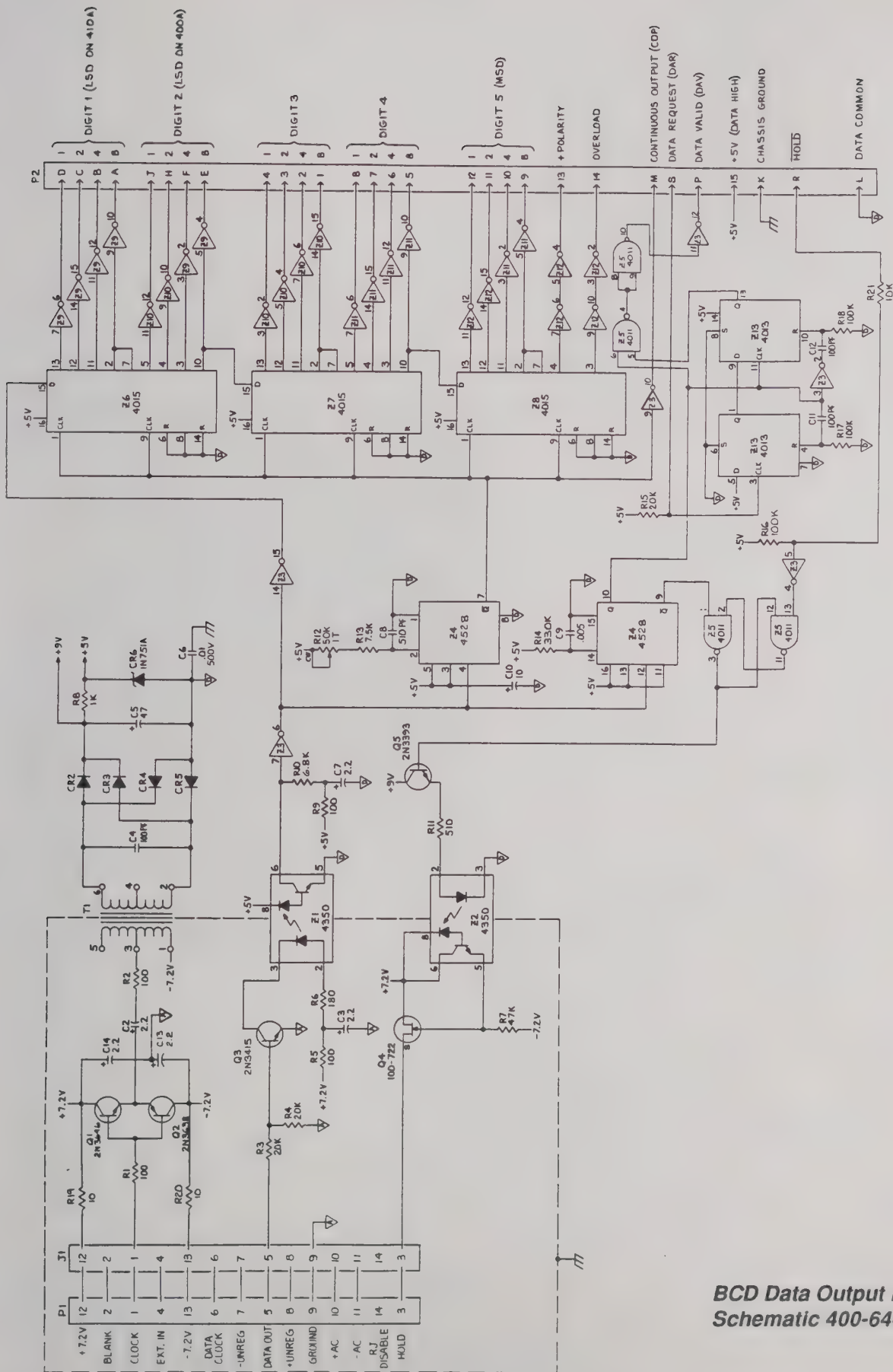
**Switch Error Indicator
Schematic 400-6420-00**



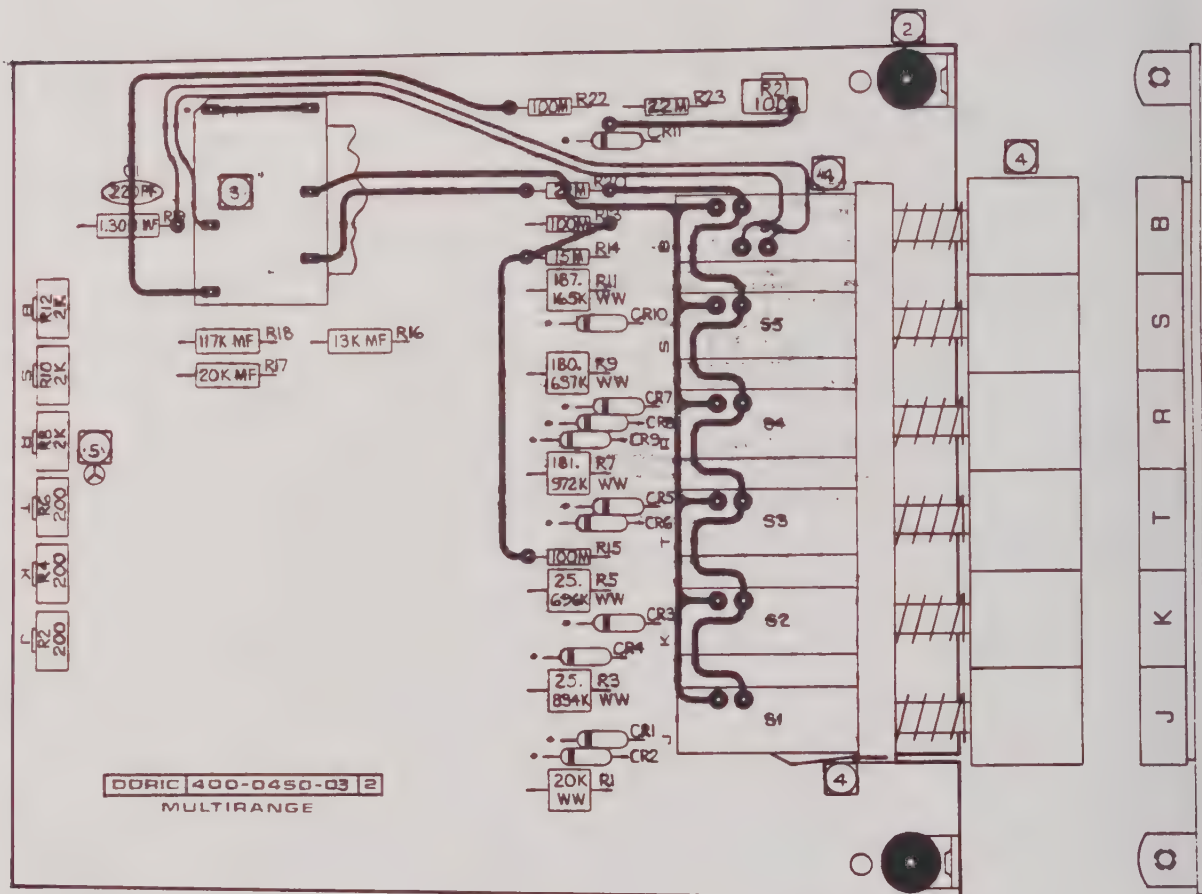
Current Loop
Schematic 400-4431-00



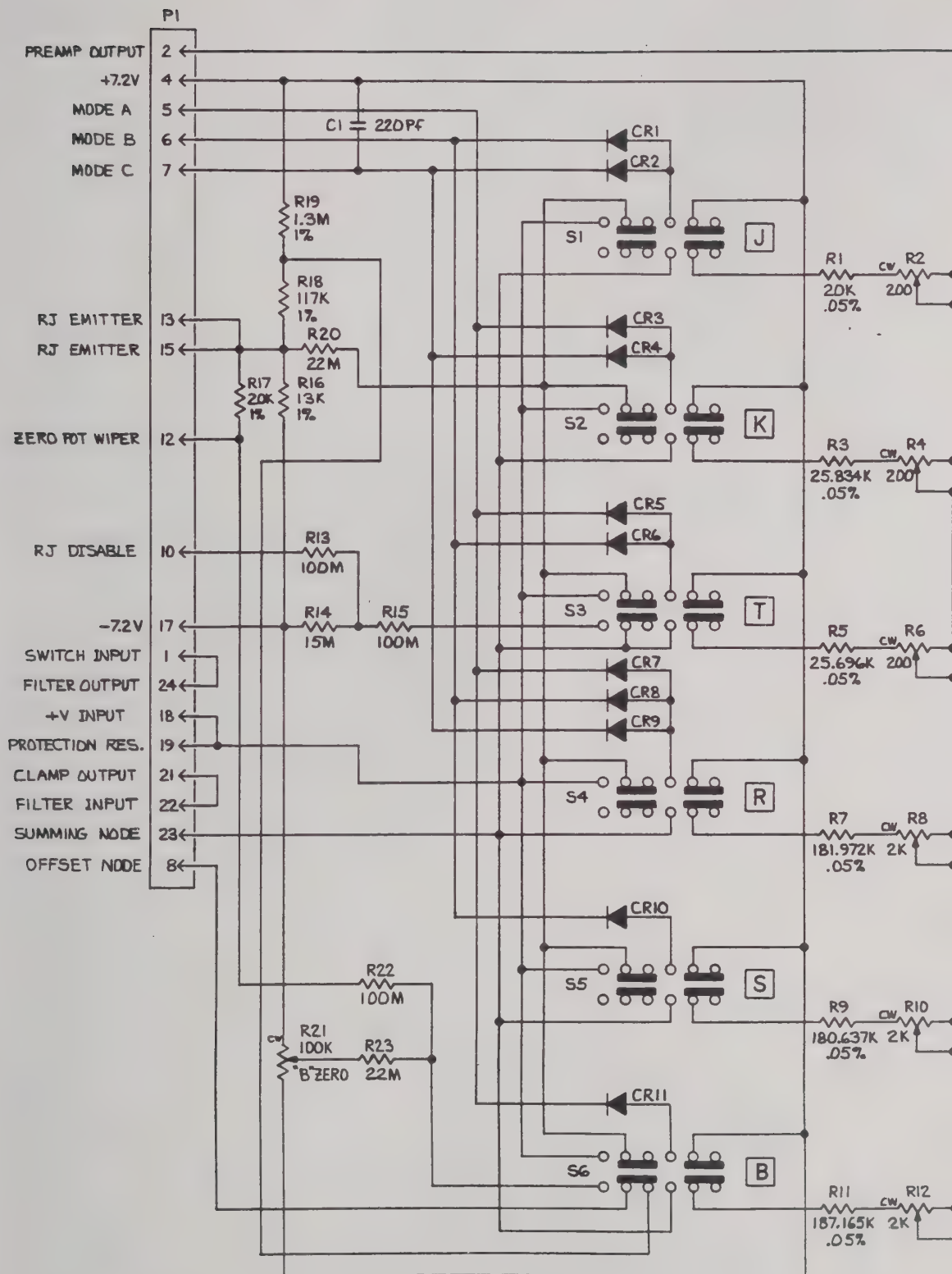




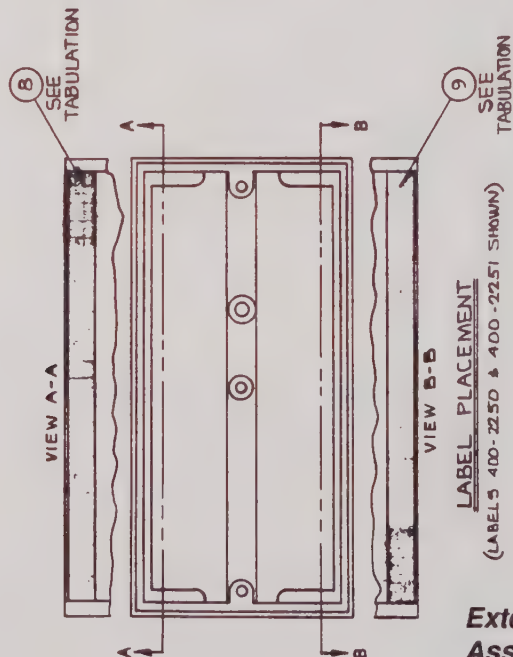
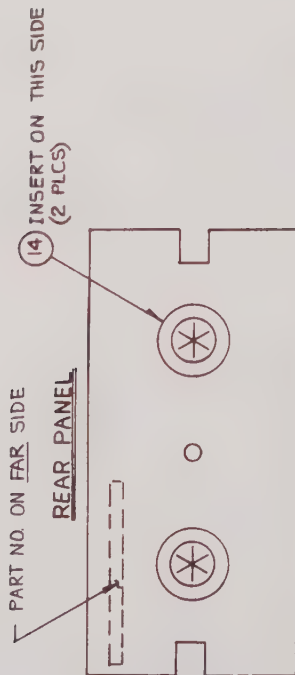
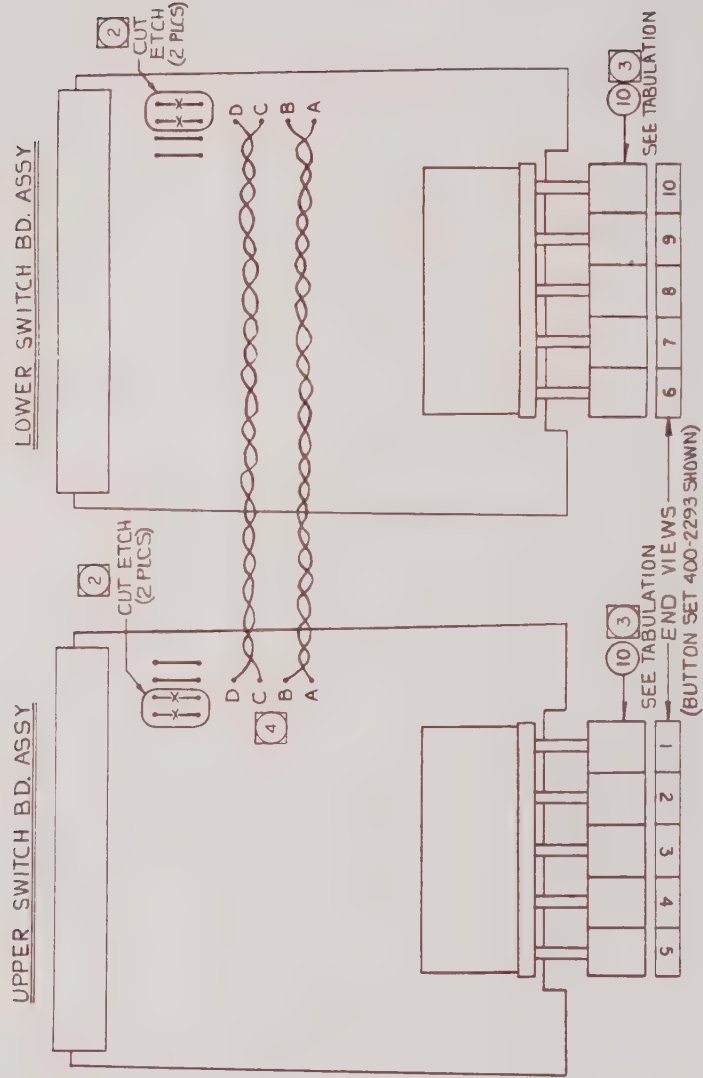
**BCD Data Output Board
Schematic 400-6440-05**



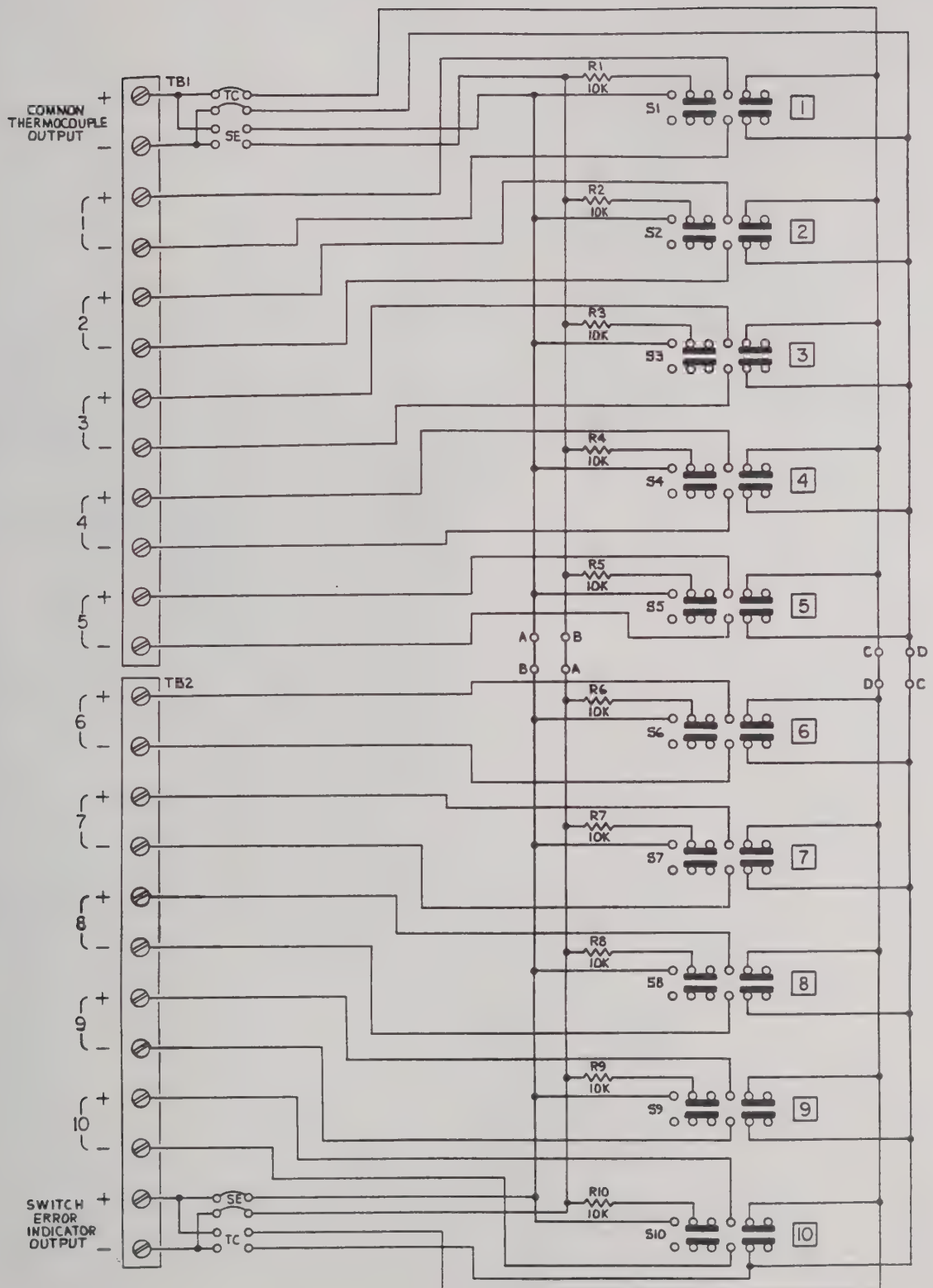
Multi-range Board
Assembly 400-4450-02



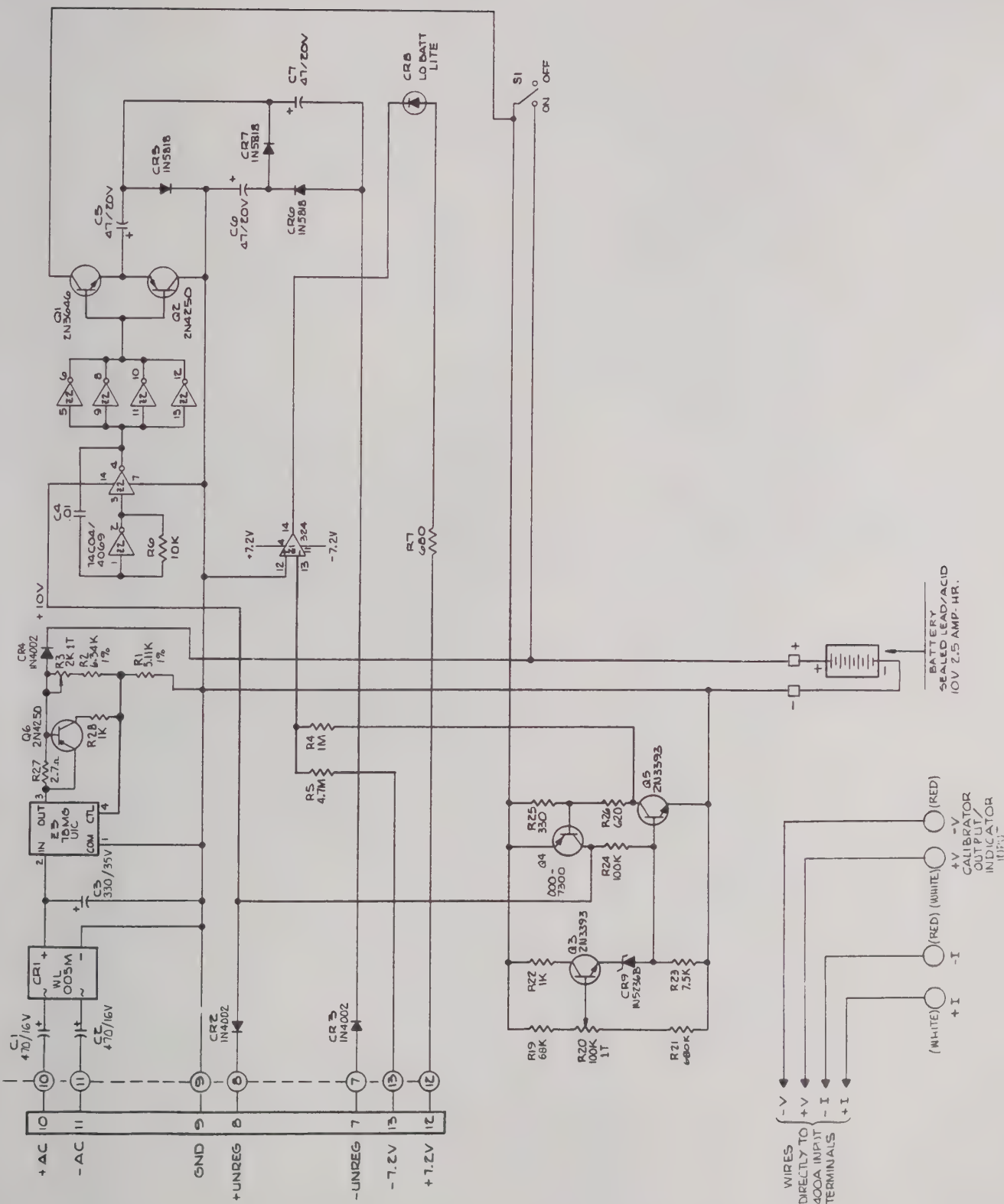
**Multi-range Board
Schematic 400-6450-01**



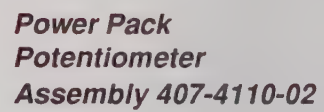
**External Switching Unit
Assembly 400-4580-01**

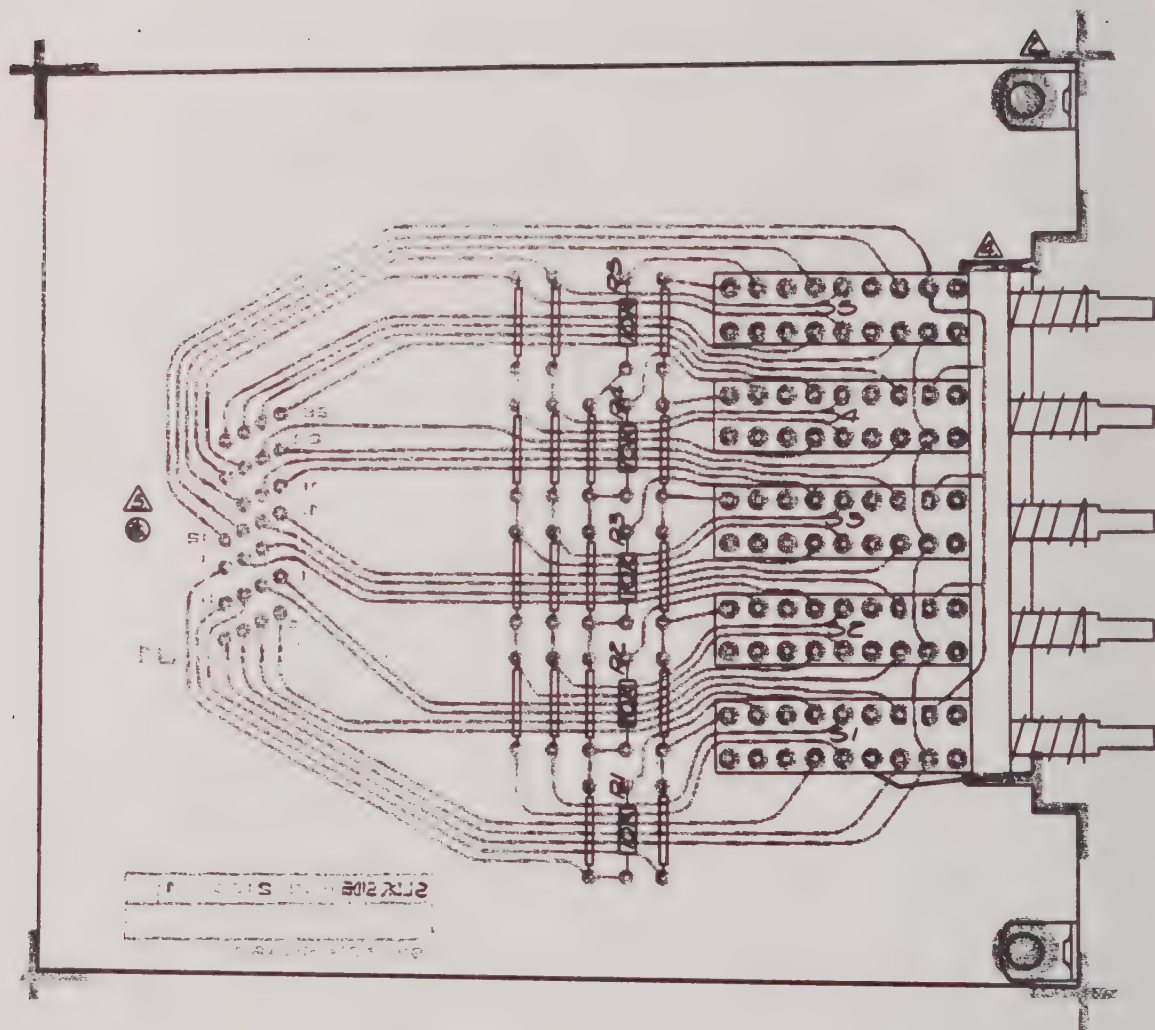


**External Switching Unit
Schematic 400-6580-00**

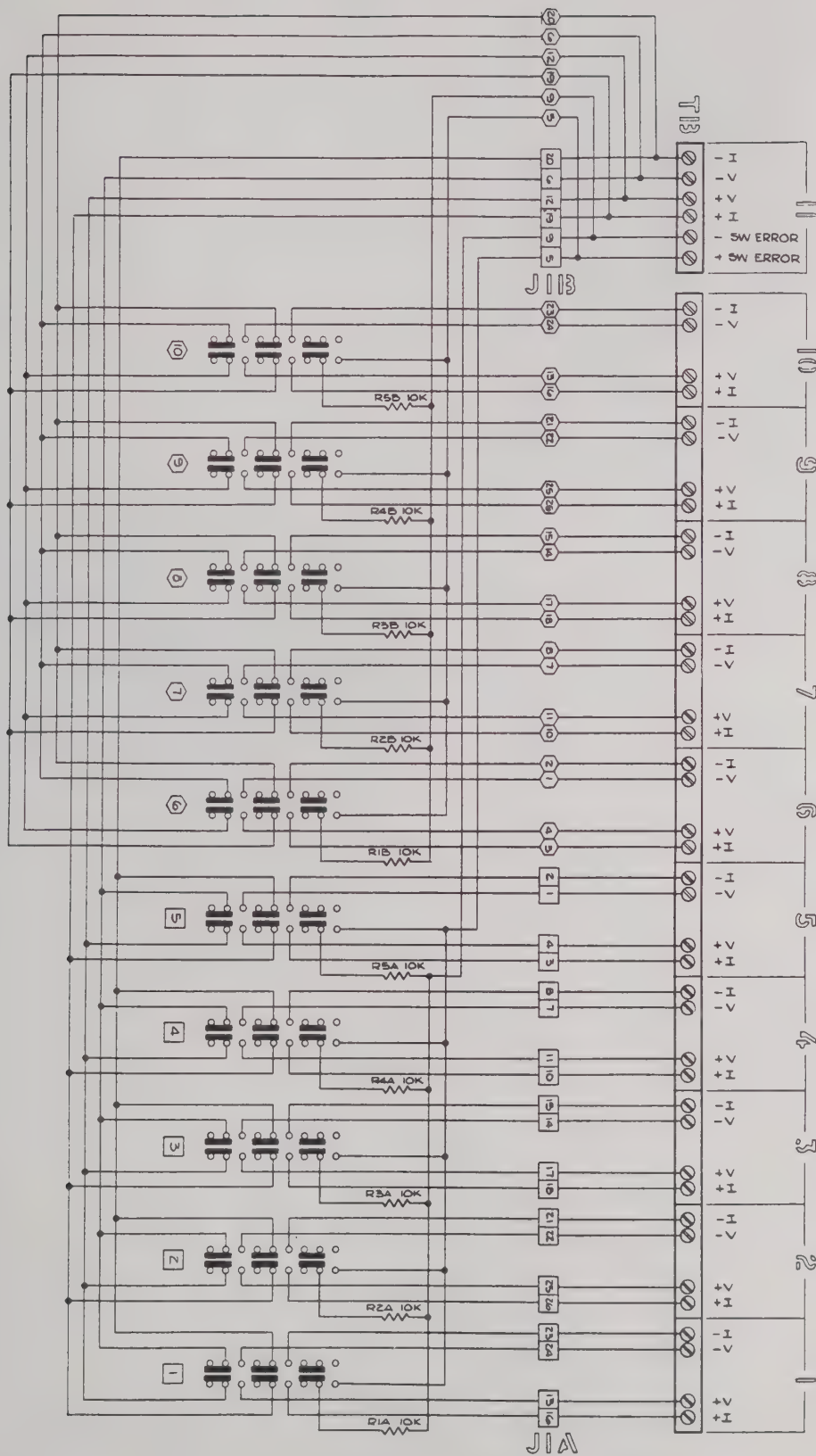


Power Pack
Schematic 406-6200-07

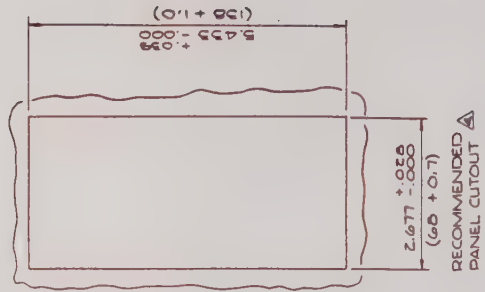
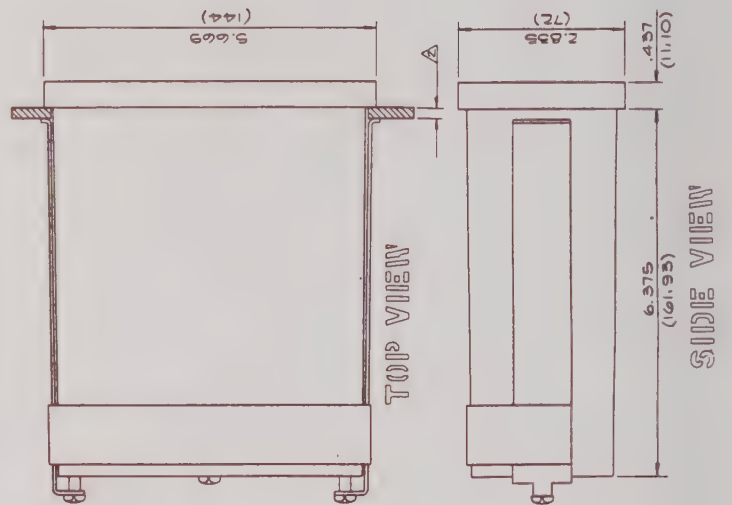
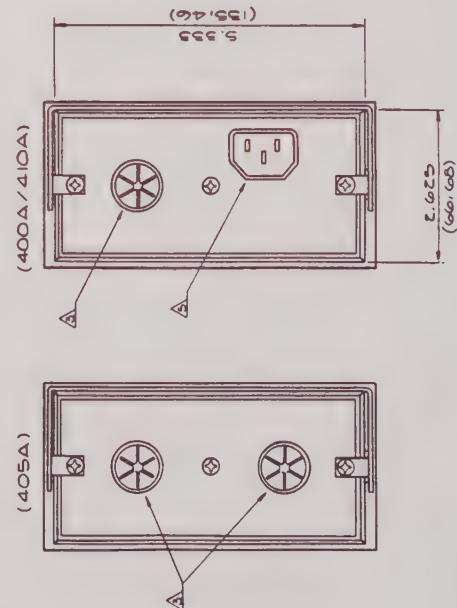


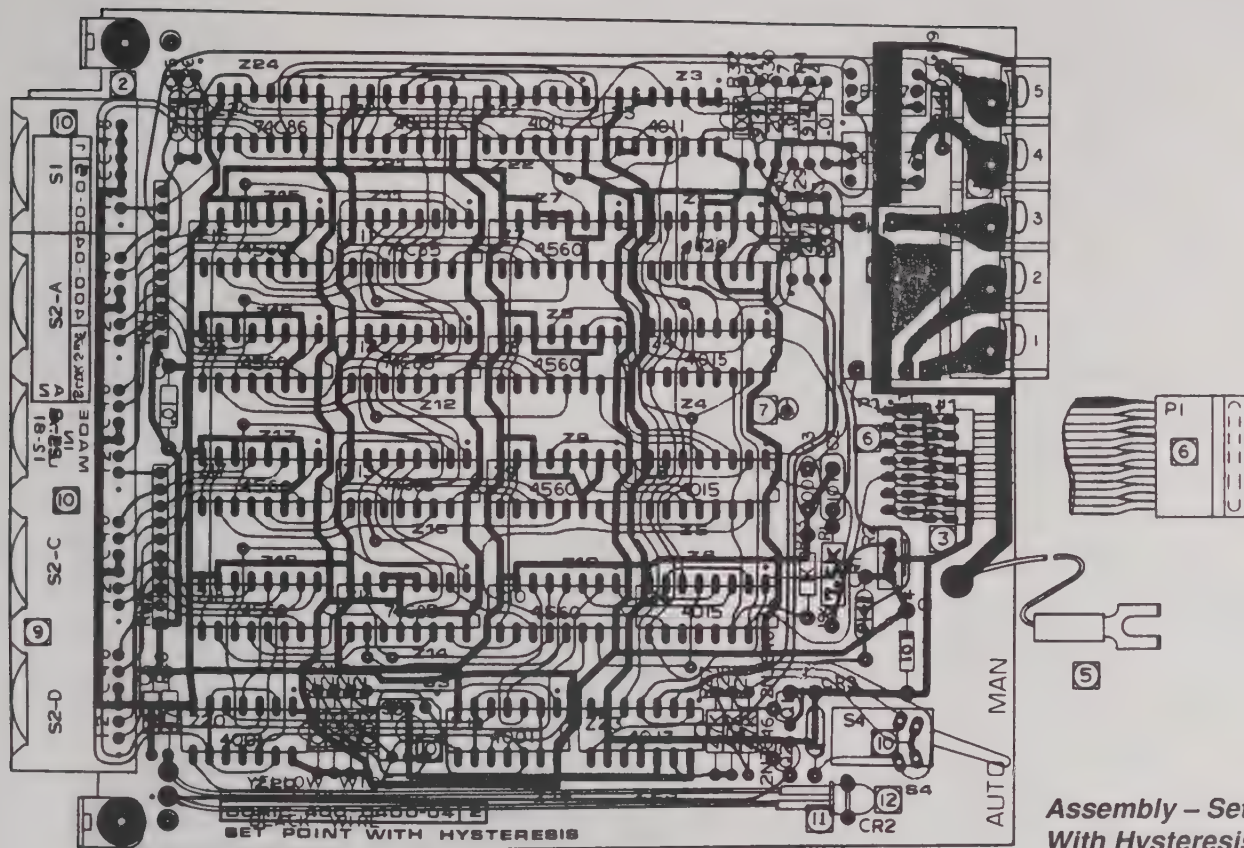


**RTD Switch Board
Assembly 409-4100-00**



RTD Switch Board
Schematic 409-6100-00

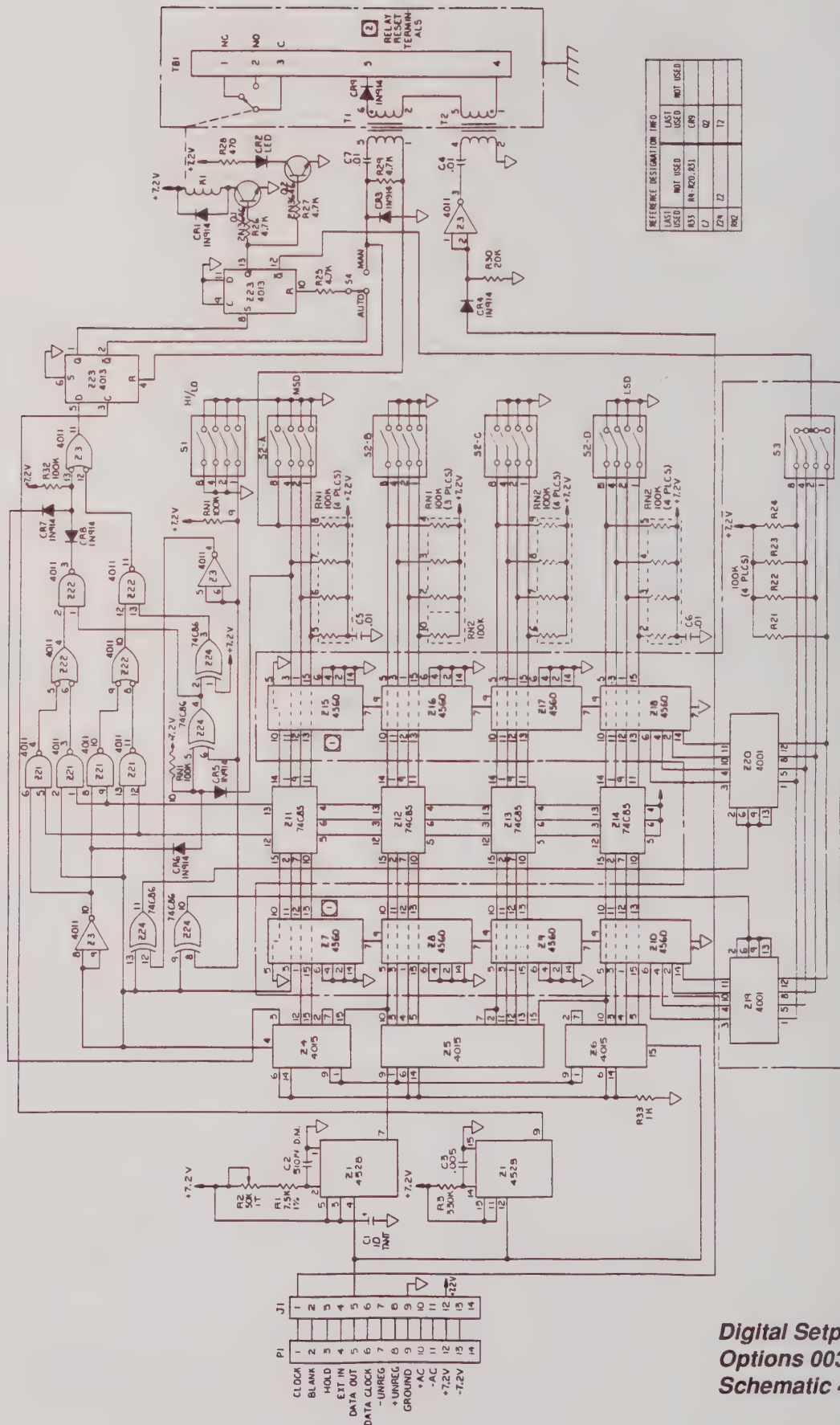




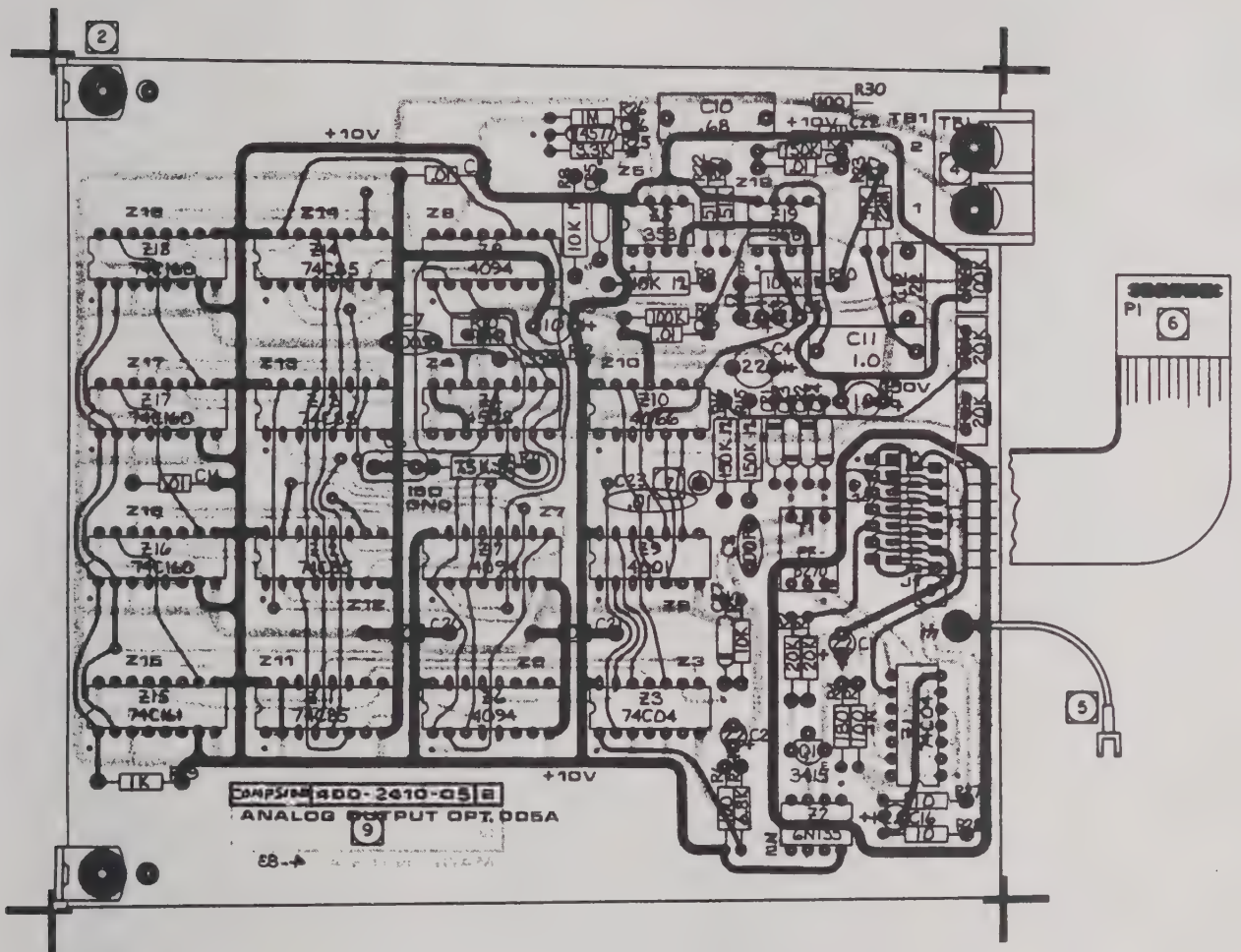
**Assembly – Setpoint
With Hysteresis
400-4400-03**

400-4401-04

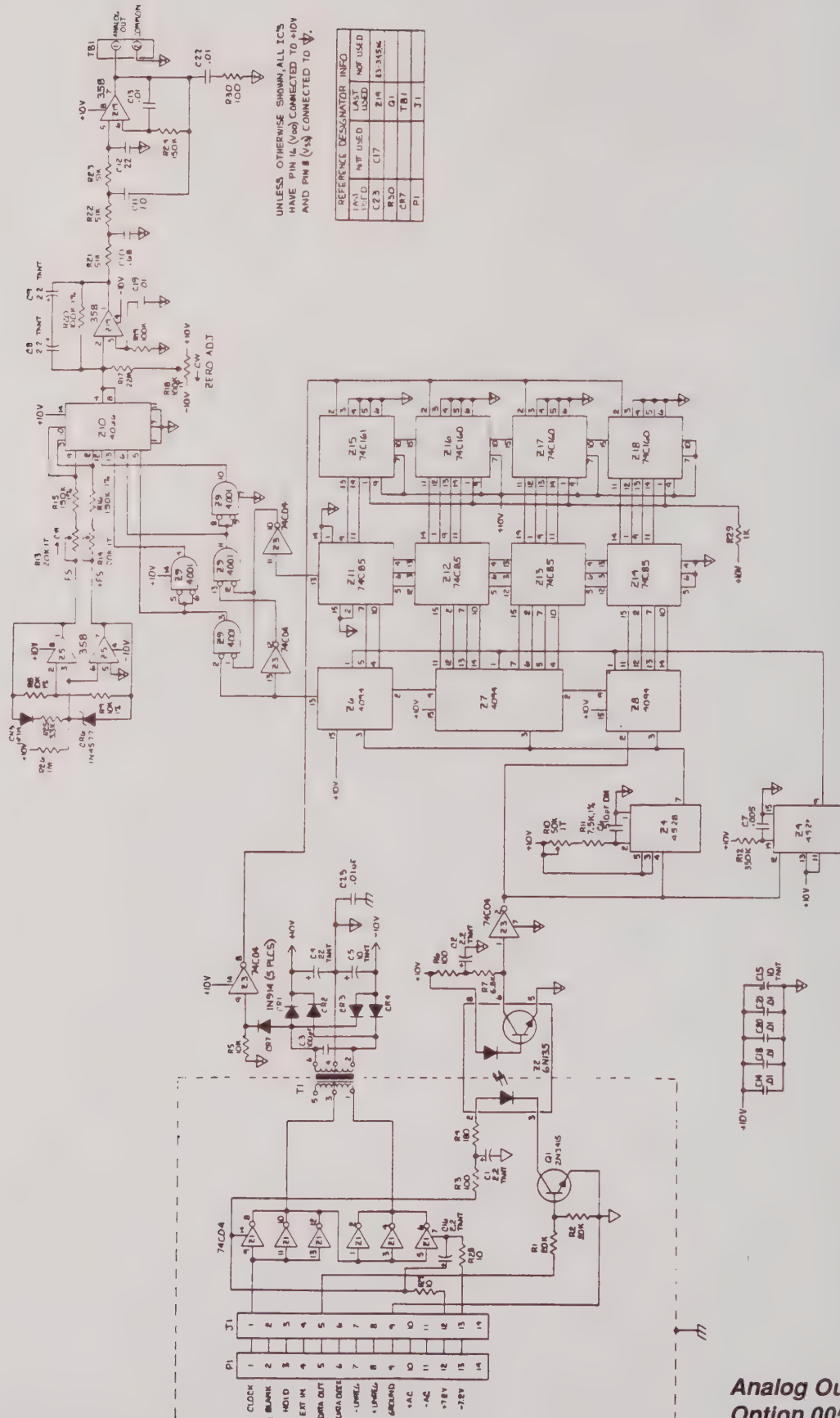
**Assembly – Setpoint
Without Hysteresis
400-4401-04**



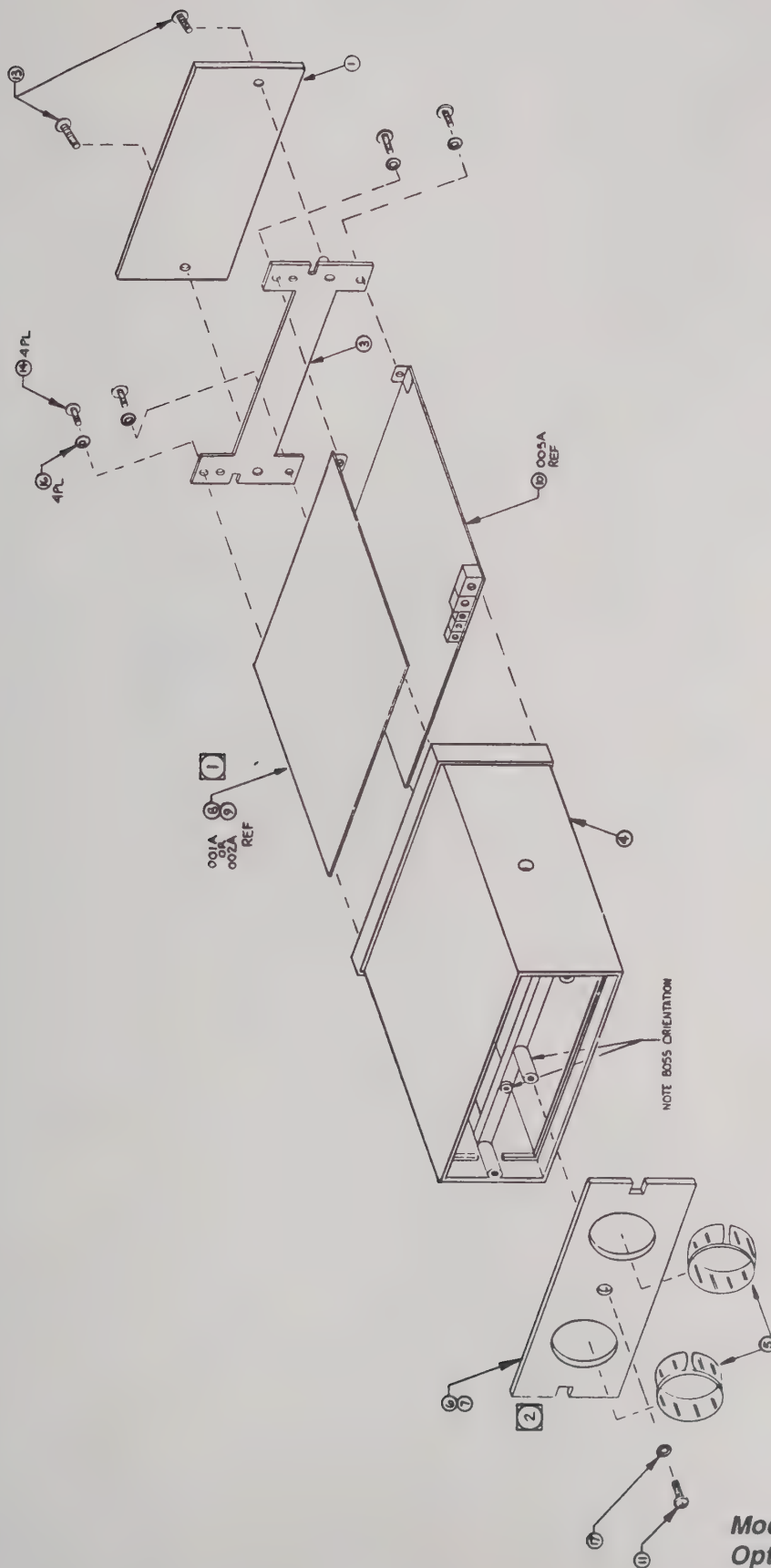
**Digital Setpoint Board
Options 003A/004A
Schematic 400-6400-02**



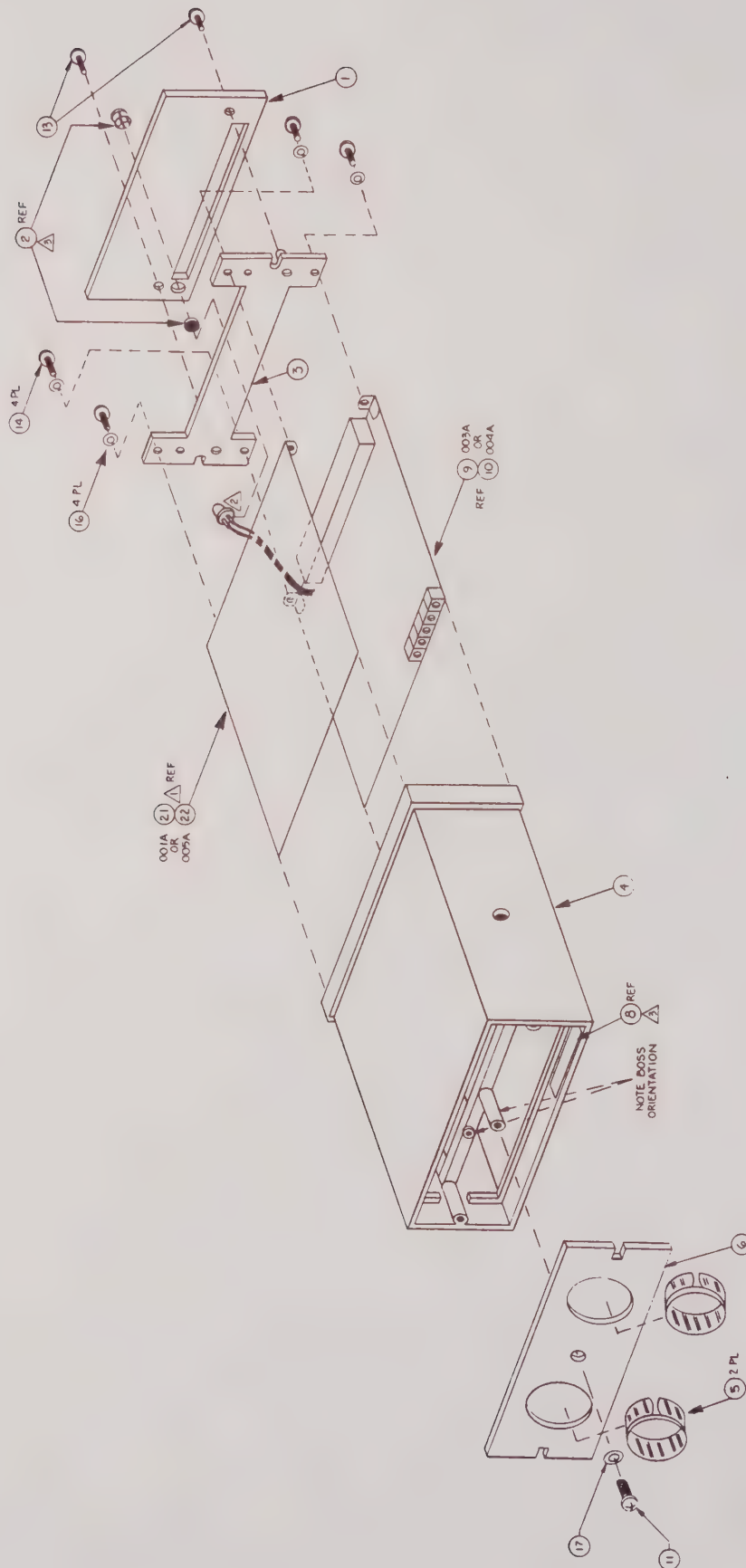
Analog Output
Assembly 400-4410-04



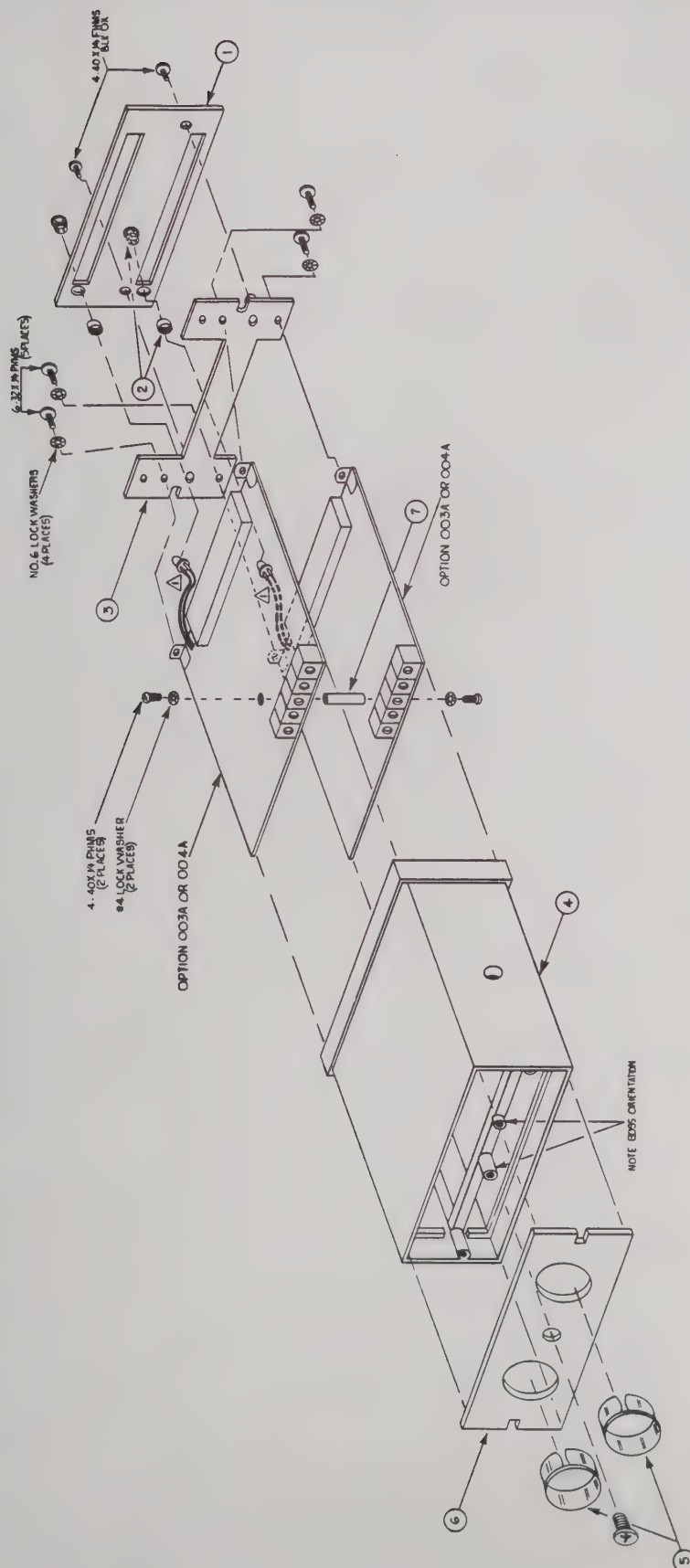
Analog Output Board
Option 005A
Schematic 400-6410-01



Model 411A (0)
Options 001A/002A/005A
Assembly 411-4000-00



Model 411A (1)
Options 001A/003A/004A/005A
Assembly 411-4001-00



Model 411A (2)
Options 003A/004A
Assembly 411-4002-00

Introduction

This section contains the electronic parts list for the Series 400A instruments, subdivided by circuit board assemblies. The list contains a brief description of the part, the quantity per assembly, part number, and part or identification number.

The manufacturer's part number has been omitted on those parts which are easily obtained by using the description. In some cases, the part is available from several manufacturers and when this occurs, only one is listed for convenience.

Title	Drawing No.	Page
Main Board (400A)	400-4180-XX	54
Main Board (410A)	400-4190-XX	55
Power Pack/Pot (407)	407-4110-XX	58
Multi-range Board	400-4450-XX	58
Power Pack (406)	406-4200-XX	59
DIN Multi-range Board	400-4130-XX	59
Switch Error	400-4420-XX	60
Switch Board	400-4430-XX	60
Switch Board	400-4431-XX	60
Data Output Board	400-4440-XX	61
Analog Module Chart		62
Setpoint Board	400-4400-XX	62
Setpoint Board	400-4401-XX	62
Analog Output Board	400-4410-XX	63
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Main Board 400A, Assembly 400-4180

Ref. Des.	Description	Qty/ Assy.	P/N
C1, C2 C3	Cap. Disc, .005 @ 1kV	3	900-085-03
C4-C6	Cap. Elctl, 390 @ 15V	3	910-470-16
C7, C8	Cap, Tant, 10 @ 35V	2	916-010-35
C9-C11	Cap, Tant, 2.2 @ 35V	3	916-033-37
C12, C13, C22	Cap, Disc, 100pF @ 1kV	3	901-011-01
C14	Cap, Polyc, .22 @ 100V	1	911-032-24
C15	Cap, Polyc, 2 @ 100V	1	911-032-05
C16	Cap, Disc 33pF @ 1kV	1	901-013-30
C17, C25, C26	Cap, Disc, .01 @ 50V	3	900-021-07
C18	Cap, Disc, 100pF	1	915-031-01
C20, C21	Cap, Disc, .02 @ 500V	2	900-082-02
C23	Cap, Mica 3pF	1	915-030-30
C24	Cap, Mica, 220pF	1	915-032-21
C27, C28	Cap, Disc, .1 @ 50V	2	900-021-02
CR1	Diode, 6.4V Zener	1	961-457-70
DS1-DS4	Display, 7-segment LED	4	968-086-00
J3	IC, Socket, 24 DIP	1	992-010-70
P1	Housing, AC Receptacle	1	400-2490-01
P1	Ground Pin, AC Receptacle	1	400-2500-01
P1	Power Pin, AC Receptacle	2	400-2510-01
P2	Connector, PC7M	1	973-380-00
Q1	Transistor, PNPA 152	1	964-040-55
Q2	Transistor, NPNA 152	1	964-040-05
Q3	Transistor, Selected	1	220-7200-01
Q4, Q5, Q8	Transistor, PNPA	3	962-425-00
Q6, Q7	FET, N-Channel	2	100-722-02
Q9-Q15	Transistor, NPNA/DR492	7	964-040-03
Q16	Transistor, NPNA	1	964-040-97
R1, R2	Res, 1/4W 5% 10	2	940-001-00
R3, R9	Res, 1/4W 5% 4.70	2	942-204-79
R4, R8, R37	Res, 1/4W 5% 1k	3	942-201-02
R5, R7	Res, 1/4W 5% 4.7k	2	942-204-72
R6, R21	Res, 1/4W 5% 1M	2	942-201-05
R10, R11	Res, 10k, 0.1%	2	922-410-02
R12	Res, 3.65k, 1%	1	920-436-51
R13	Pot, 1k Cermet	1	960-011-25
R14	Pot, 200k Cermet	1	960-012-09
R15	Res, 2W, 5% 10k	1	942-501-03
R16, R31	Res, 1/4W 5% 220k	2	942-202-24
R17	Res, 1/4W 5% 22	1	942-202-20
R18, R32	Res, 1/4W 5% 2.2M	2	942-202-25
R19, R22	Pot, 100k Cermet	2	960-011-18
R20	Res, 1k, 1%	1	920-410-01
R23	Res, 56.2k, 1%	1	920-456-22
R24, R34 R36, R42 R43	Res, 1/4W 5% 100k	5	942-201-04
R25	Res, 1.96M, 1%	1	921-491-64
R29	Pot, 10k Cermet	1	960-011-16

Main Board 400A, Assembly 400-4180 (Continued)

Ref. Des.	Description	Qty/ Assy.	P/N
R30	Res, 1/4W 5% 22k	1	942-202-23
R33	Res, 953, 1%	1	921-495-33
R35	Res, 1/4W 5% 100	1	942-201-01
R38	Pot, 2k Cermet	1	960-012-08
R39	Res, 1/4W 1% 10.4k	1	920-410-42
R40	Res, 1.4W 5% 15M	1	942-201-56
R41	Res, 1.4W 5% 4.7m	1	942-204-75
R44	Pot, 50k Cermet	1	960-015-04
R45	Pot, 100k Cermet	1	960-011-09
R46, R47	Res, 1/4W 5% 10k	2	942-201-03
R48	Pot, 20k Cermet	1	960-0500-03
S2	Switch, 6-pole DIP	1	969-050-00
T1	Transformer, Power	1	400-7040-00
TB1	Terminal Strip	1	973-010-37
Z1, Z3	IC, Graded 4016	2	000-7700-00
Z2, Z4	IC, Op-7, Op. Amp.	2	965-607-00
Z5, Z6	IC, Op. Amp.	2	965-592-01
Z7	IC, Inv, NOR, NAND	1	965-618-00
Z8	IC, Op. Amp. Dual	1	965-617-00
Z9	IC, PMOS LSI	1	000-7500-00 or 000-7501-00
Z10	IC, Hex Driver	1	965-619-00
Z11	Resistor Network 39 Ω	1	950-003-90
Z12	Rectifier Bridge	1	966-002-26
	IC Socket, 40 DIP	1	992-010-18
	Cable, Flat	1	993-100-00

Main Board 410, Assembly 400-4190

Ref. Des.	Description	Qty/ Assy.	P/N
C1, C2, C3	Cap. Disc, .005 @ 1kV	3	900-085-03
C4-C6	Cap. Elctlt, 390 @ 15V	3	910-470-16
C7, C8	Cap, Tant, 10 @ 35V	2	916-010-35
C9-C11	Cap, Tant, 2.2 @ 35V	3	916-033-37
C12, C13,	Cap, Disc, 100pF @ 1kV	2	901-011-01
C14	Cap, Polyc, .22 @ 100V	1	911-032-24
C15	Cap, Polyc, 2 @ 100V	1	911-032-05
C16	Cap, Mica 3pF	1	915-030-30
C17, C25,	Cap, Disc, .01 @ 50V	3	900-021-07
C26,			
C18	Cap, Disc, 100pF	1	915-031-01
C20, C21	Cap, Disc, .02 @ 500V	2	900-082-02
C24	Cap, Mica, 220pF	1	915-032-21
C27, C28	Cap, Disc, .1 @ 50V	2	900-021-02
CR1	Diode, 6.4V Zener	1	961-457-70
DS1-DS4	Display, 7-segment	5	968-086-00
J3	IC Socket, 24 DIP	1	992-010-70
P1	Housing, AC Receptacle	1	400-2490-01
P1	Ground Pin, AC Receptacle	1	400-2500-01

Main Board 410, Assembly 400-4190 (cont'd.)

Ref. Des.	Description	Qty/ Assy.	P/N
P1	Power Pin, AC Receptacle	2	400-2510-01
P2	Connector, PC7M	1	973-380-00
Q1	Transistor, PNPA 152	1	964-040-55
Q2	Transistor, NPNA 152	1	964-040-05
Q3	Transistor, Selected	3	220-7200-01
Q4, Q5, Q8	Transistor, PNPA	3	962-425-00
Q6, Q7	FET, N-Channel	2	100-722-02
Q9-Q15	Transistor, NPNA/DR492	7	964-040-03
Q16	Transistor, NPNA	1	964-040-97
R1, R2	Res, 1/4W 5% 10	2	940-001-00
R3, R9	Res, 1/4W 5% 4.7	2	942-204-79
R4, R8, R37	Res, 1/4W 5% 1k	3	942-201-02
R5, R7	Res, 1/4W 5% 4.7k	2	942-204-72
R6, R21	Res, 1.4W 5% 1M	2	942-201-05
R10, R11	Res, WW 10k	1	934-211-75
R12	Res, 3.65k, 1%	1	920-436-51
R13	Pot, 1k Cermet	1	960-011-25
R14	Pot, 100K Cermet	1	960-011-09
R15	Res, 2W, 5% 10k	2	942-501-03
R16, R31	Res, 1/4W 5% 220k	2	942-202-24
R17	Res, 1/4W 5% 22	1	942-202-20
R18, R32	Res, 1/4W 5% 2.2M	2	942-202-25
R19, R22	Pot, 100k Cermet	2	960-011-18
R20	Res, WW, 1k	1	934-211-74
R23	Res, WW 56.25k	1	937-201-14
R24, R34	Res, 1/4W 5% 100k	4	942-201-04
R42, R43			
R25	Res, 2.02M 1%	1	921-420-24
R26	Res, 1/4W 5% 22M	1	942-202-26
R27	Res, 1/4W 5% 10M	1	942-201-06
R29	Pot, 10k Cermet	1	960-011-16
R30	Res, 1/4W 5% 22k	1	942-202-23
R33	Res, WW, 990.75k	1	937-201-13
R35	Res, 1/4W 5% 100	1	942-201-01
R36	Res, 1/4W 5% 390k	1	942-203-94
R38	Pot, 2k Cermet	1	960-012-08
R39	Res, 1/4W 1% 10.4k	1	920-410-42
R40	Res, 1/4W 5% 15M	1	942-201-56
R41	Res, 1.4W 5% 4.7M	1	942-204-75
R44	Pot, 50k Cermet	1	960-015-04
R45	Pot, 25k Cermet	1	960-012-53
R46, R47	Res, 1/4W 5% 10k	2	942-201-03
R48	Pot, 20k Cermet	1	960-0500-03
S2	Switch, 6-pole DIP	1	969-050-00
T1	Transformer, Power	1	400-7040-01
TB1	Terminal Strip	1	973-010-37
Z2	IC, Op. Amp.	1	965-607-00
Z1, Z3	IC, Graded 4016	2	00-7700-00
Z4, Z5	IC, Op. Amp.	2	965-616-00
Z6	IC, Op. Amp.	1	965-592-01
Z7	IC, Inv, NOR, NAND	1	965-618-00
Z8	IC, Op. Amp., Dual	1	965-617-00

Main Board 410, Assembly 400-4190 (cont'd.)

Ref. Des.	Description	Qty/ Assy.	P/N
Z9	IC, PMOS LSI	1	00-7500-00 or
		1	000-7501-00
Z10	IC, Hex Driver	1	965-619-00
Z11	Resistor Network 39 Ω	1	960-003-90
Z12	Rectifier Bridge	1	966-002-26
	IC Socket, 40 DIP	1	992-010-18
	Cable, Flat	1	993-100-00

Power Pack Potentiometer, Assembly 407-4110

Ref. Des.	Description	Qty/ Assy.	P/N
C1, C2	Cap. Elctlt. 390 @ 15V	2	910-470-16
C3	Cap. Elctlt. 270 @ 40V	1	910-270-40
C4	Cap. Disc. 0.1 @ 50V	1	900-021-07
C5-C7	Cap. Tant 47 @ 20V	3	961-471-20
CR1	Rectifier Bridge	1	966-002-26
CR2-CR7	Rectifier, 100V	6	966-002-00
CR8	LED, Red	1	968-010-10
CR9	Diode, 7.5V	1	961-523-62
Q1	Transistor, NPNSH106	1	962-364-60
Q2, Q6	Transistor, PNPA	1	962-425-00
Q3, Q5	Transistor, NPNA98-5	2	962-339-30
Q4	Transistor, PNPA152	1	964-040-55
R1	Res, 5.11k, 1%	1	920-451-11
R2	Res, 6.34k, 1%	1	920-463-41
R3	Pot, 2k Cermet	1	960-012-08
R4, R27	Res, 1/4W 5% 1M	2	942-201-05
R5, R13	Res, 1/4W 5% 4.7M	2	942-204-75
R6	Res, 1/4W 5% 30k	1	942-203-03
R7	Res, 1/4W 5% 680	1	942-206-81
R8	Res, 1k, 1%	1	920-410-01
R9	Res, 2.49k	1	920-424-91
R10	Pot, 10k WW	1	960-011-21
R11	Res, 5.49k	1	920-454-91
R12/SW2	Pot/Switch, 100k	1	960-011-35
R14	Res, 490, 1%	1	920-349-00
R15	Res, 10, 1%	1	920-310-09
R16, R18	Res, 20k, 1%	2	920-420-02
R17	Res, 499, 1%	1	920-449-90
R19, R24	Res, 1/4W 5% 100k	2	942-201-04
R20	Pot, 100k Cermet	1	960-011-18
R21	Res, 1/4W 5% 680k	1	942-206-84
R22, R26, R28	Res, 1/4W 5% 1k	3	942-201-02
R23	Res, 1/4W 5% 10k	1	942-201-03
R25	Res, 1/4W 5% 330	1	942-203-31
R29	Res, 1/4W 5% 2.7	1	942-202-79

Power Pack Potentiometer, Assembly 407-4100 (cont'd.)

Ref. Des.	Description	Qty/ Assy.	P/N
SW1	Switch Rocker	1	969-020-00
SW2	See R12		
Z1	IC, Quad Op. Amp.	1	965-599-00
Z2	IC, Hex Inverter	1	965-587-05
Z3	Regulator	1	965-644-00
	Battery Assembly	1	407-4200-02

Multi-range Board, Assembly 400-4450

Ref. Des.	Description	Qty/ Assy.	P/N
C1	Cap, Disc 220pF @ 1kV	1	901-012-21
CR1-CR11	Diode	11	961-091-40
R1	Res, WW 20k	1	934-212-03
R2, R4, R6	Pot, 200 Cermet	3	960-012-04
R3	Res, WW, 25.834k	1	934-202-06
R5	Res, WW, 25.696k	1	934-202-05
R7	Res, WW, 181.972k	1	934-202-02
R8, R10, R12	Pot, 2k Cerment	3	960-012-08
R9	Res, WW, 180.63k	1	934-202-01
R11	Res, WW 187.165k	1	934-202-03
R13, R15, R22	Res, 1/4W 10% 100M	3	943-201-07
R14	Res, 1/4W 5% 15M	1	942-201-56
R16	Res, 13k, 1%	1	920-413-02
R17	Res, 20k 1%	1	920-420-02
R18	Res, 117k, 1%	1	920-411-73
R19	Res, 1.30M, 1%	1	922-413-04
R20	Res, 1/4W 5% 22M	1	942-202-26
R21	Pot, 100k Cermet	1	960-011-18
S1-S6	Switch	1	969-010-21
	Engraved Button Set	1	400-2290-00
	Cable, 3 inch	1	993-100-00

Power Pack 406, Assembly 406-4200

Ref. Des.	Description	Qty/ Assy.	P/N
C1, C2	Cap, Elct 390 @ 15V	2	910-470-16
C3	Cap, Elct 270 @ 40V	1	910-270-40
C4	Cap, Disc .01 @ 50V	1	900-021-07
C5-C7	Cap, Tant 47 @ 20V	3	916-471-20
CR1	Rectifier Bridge	1	966-002-26
CR2-CR7	Rectifier, 100V	6	966-002-00
CR8	LED, Red.	1	968-010-10
CR9	Diode (7.5V)	1	961-523-62
Q1	Transistor	1	962-364-60
Q2, Q6	Transistor	2	962-425-00
Q3, Q5	Transistor, NPNA98-5	2	962-339-30
Q4	Transistor, PNPA 152	1	964-040-55
R1	Res. 5.11k, 1%	1	920-451-11
R2	Res, 6.34k, 1%	1	920-463-41
R3	Pot, 2k Cermet	1	960-012-08
R4	Res, 1/4W 5% 1M	1	942-201-05
R5	Res, 1/4W 5% 4.7M	1	942-204-75
R6	Res, 1/4W 5% 30k	1	942-203-03
R7	Res, 1/4W 5% 680k	1	942-206-81
R19, R24	Res, 1/4W 5% 100k	2	942-201-04
R20	Pot, 100k Cermet	1	960-011-18
R21	Res, 1/4W 5% 680k	1	942-206-84
R22, R26, R28	Res, 1/4W 5% 1k	3	942-201-02
R23	Res, 1/4W 5% 10k	1	942-201-03
R25	Res 1/4W 5% 330	1	942-203-31
R27	Res, 1/4W 5% 2.7	1	942-202-79
SW1	Rocker Switch	1	969-020-00
Z1	IC, Quad. Op. Amp.	1	965-599-00
Z2	IC, Hex Inverter	1	965-587-05
Z3	Regulator	1	965-644-00
	Battery Assembly	1	407-4200-02

DIN Multi-range Board, Assembly 400-4130

Ref. Des.	Description	Qty/ Assy.	P/N
CR1-CR11	Diode	11	961-091-40
R1, R3, R5, R7, R11	Pot, 200 Cermet	5	960-012-04
R2	Res. WW 19.489k	1	934-216-69
R4	Res, WW 25.834k	1	934-202-06
R6	Res, WW 25.486k	1	934-216-70
R8	Res, WW 16.826k	1	934-216-68
R9	Pot, 10 Cermet	1	960-011-19
R10	Res, WW 857.3	1	937-201-19

DIN Multi-range Board, Assembly 400-4130 (cont'd.)

Ref. Des.	Description	Qty/ Assy.	P/N
R12	Res, WW 31k	1	937-201-18
R13	Res. WW 71.61k	1	937-201-20
R14	Res, WW 71.71k	1	937-201-21
R15	Pot, 50k Cermet	1	960-015-08
R16, R17	Pot, 100k Cermet	2	960-011-18
R18, R20	Res, 1/4W 10% 100M	4	943-201-07
R25, R29			
R19	Res, 1/4W 5% 15M	1	942-201-56
R21	Res, 13k, 1%	1	920-413-02
R22	Res, 20k, 1%	1	920-420-02
R23	Res, 117k, 1%	1	920-411-73
R24	Res, 1.30M 1%	1	922-413-04
R26, R28	Res, 1/4W 5% 22M	2	942-202-26
R27	Res, 1.2605M, 0.1%	1	922-412-64
S1-S6	Switch	1	969-010-24
	Engraved Button Set	1	400-2291-00
	Cable, 3 inch	1	993-100-10

Switch Error Indicator, Assembly 400-4420

Ref. Des.	Description	Qty/ Assy.	P/N
Q1	Transistor, PNP	1	962-425-00
Q2	Transistor, NPN	1	962-339-30
R1, R2	Res, 1/4W 5% 10k	2	942-201-03
R3	Res, 1/4W 5% 6.8k	1	942-206-82
TB1	Terminal Strip	1	973-010-32
	Cably Assy, I/O	1	993-300-02

Switch Board, Assembly 400-4430; 400-4431

Ref. Des.	Description	Qty/ Assy.	P/N
R1-R5	Res, 1/4W 5% 10k	5	942-201-03
S1-S5	Switch	1	969-010-23
	Terminal Strip	1	973-010-34
4431 Only: CR1-CR10	Rectifier, 100V	10	966-002-00

Data Output Board, Assembly 400-4440

Ref. Des.	Description	Qty/ Assy.	P/N
C2, C3, C7, C13, C14	Cap, Tant, 2.2 @ 35V	5	916-220-04
C4, C11, C12	Cap, Disc, 100pF @ 1kV	3	901-011-01
C5	Cap, Tant, 47@ 20V	1	916-471-20
C6	Cap, Disc, .01 @ 500V	1	900-021-04
C8	Cap, Mica, 510pF	1	915-035-11
C9	Cap, Disc, .005 @ 1kV	1	900-085-03
C10	Cap, Tant, 10 @ 35V	1	916-010-35
CR1	Diode, 1N457A	1	961-045-70
CR2-CRG	Diode, 1N914	4	961-091-40
CR6	Diode, 1N751A	1	961-075-11
J1	Connector, Cable 14F	1	973-390-00
Q1	Transistor, 2N3646	1	962-364-60
Q2	Transistor, 2N3638	1	962-363-80
Q3	Transistor, 2N3415	1	962-341-50
Q4	FET, U1742C	1	100-722-02
Q5	Transistor, 2N3393	1	962-339-30
R1, R2, R5, R9	Res, 1/4W 5% 100	4	942-201-01
R3, R4, R15	Res, 1/4W 5% 20k	3	942-202-03
R5	Res, 1/4W 5% 1k		942-210-01
R6	Res, 1/4W 5% 180	1	942-201-81
R7	Res, 1/4W 5% 47k	1	942-204-73
R8	Res, 1/4W 5% 1k	1	942-201-02
R10	Res, 1/4W 5% 6.8k	1	942-206-82
R11	Res, 1/4W 5% 510	1	942-205-11
R12	Pot, 10k Cermet	1	960-011-16
R13	Res, RN60C, 5.11k	1	920-451-11
R14	Res, 1/4W 5% 330k	1	942-203-34
R16-R18	Res, 1/4W 5% 100k	3	942-201-04
R19, R20	Res, 1/4W 5% 10	2	942-201-00
R21	Res, 1/4W 5% 10k	1	942-201-03
T1	Transformer	1	967-020-10
Z1, Z2	IC, Optical Isolator	2	965-570-00
Z3, Z9-Z12	IC, Hex Inverter, CMOS	5	965-587-21
Z4	IC, Multi-vibrator	1	965-587-72
Z5	IC, 4-2 IN NAND CMOS	1	965-587-02
Z6-Z8	IC, Dual SR CMOS	3	965-587-03
Z13	IC, Dual DFF, CMOS	1	965-587-23
	Connector	1	973-380-00
	Mating Connector	1	973-010-40
	Hood, Connector	1	973-010-41
	Key, Connector	1	973-021-05

Analog Programming Module Chart

Part #	Range	Part #	Range	Part #	Range
400-4530-00	J	400-4540-00	P3	400-4545-01	K3
400-4531-00	K	400-4539-00	P4	400-4546-01	K4
400-4532-00	T	400-4548-00	P5	400-4550-00	K5
400-4533-00	R	400-4549-00	P6	400-4551-00	TF
400-4534-00	S	400-4541-00	I1	400-4552-00	TC
400-4535-00	B	400-4542-00	I2	400-4553-00	C3
400-4536-00	FC	400-4547-01	I3	400-4554-00	C4
400-4537-00	CC	400-4543-00	K1	400-4555-00	2J
400-4538-00	E	400-4544-00	K2	400-4556-00	2T

Setpoint Board (Options 003A/004A), Assemblies 400-4400/400-4401

Ref.		Qty		
Des.	Description	003A	004A	P/N
C1	Cap, Tant, 10 @ 10V	1	1	916-010-10
C2	Cap, Mica, 510pF	1	1	915-035-11
C3	Cap, Disc, .005 @ 1kV	1	1	900-085-03
C4-C7	Cap, Disc, .01 @ 50V	4	4	900-021-07
CR1, CR3, CR4	Diode, 1N914	3	3	961-091-40
CR2	LED, Red	1	1	993-300-07
J1	Connector, PC7M	1	1	973-380-00
K1	Relay	1	1	970-011-01
Q1, Q2	Transistor, 2N3646	2	2	962-364-60
R1	Resistor, 2.49k	1	1	920-424-91
R2	Potentiometer, 10k	1	1	960-011-16
R3	Resistor, 1/4W 5% 330k	1	1	942-203-34
RN1, RN2	Resistor Network 100k	2	2	950-010-03
R21-R24, R32	Resistor, 1/4W 5% 100k	1	5	942-201-04
R25-R27, R29	Resistor, 1/4W 5% 4.7k	4	4	924-204-72
R28	Resistor, 1/4W 5% 470	1	1	942-204-71
R30	Resistor, 1/4W 5% 20k	1	1	942-202-03
R33	Resistor, 1/4W 5% 1k	1	1	942-201-02
S1	Switch, Thumbwheel	1	1	969-011-27
S2	Switch, 4-wheel	1	1	200-7020-01
S4	Switch, Toggle	1	1	969-010-73
S3	Switch	0	1	969-011-28
T1, T2	Transformer	2	2	967-020-10
TB1	Terminal, 5 position	1	1	973-010-68
Z1	IC, Mono-vibrator	1	1	965-587-72
Z3, Z21, Z22	IC, 4-2 IN NAND	3	3	965-587-02
Z4-Z6	IC, Dual, CMOS	3	3	965-587-03
Z7-Z10	C, BCD Adder	0	8	965-587-63
Z11-Z14	IC, Quad Comp	4	4	965-587-64
Z19, Z20	IC, 4-2IN NOR	0	2	965-587-01
Z23	IC, Dual, CMOS	1	1	965-587-23
Z24	IC, 4-Excl or CMOS	1	1	965-565-05
	Connector, Cable	1	1	973-390-00

Analog Output Board (Option 005A), Assembly 400-4410-XX

Ref. Des.	Description	Qty/ Assy.	P/N
C1, C2, C8, C9, C16	Cap, Tant, 2.2 @ 35V	5	916-220-04
C3	Cap, Disc. 100pF @ 1kV	1	901-011-01
C4	Cap. 22 @ 35V	1	916-220-05
C5, C15	Cap, Tant, 10 @ 35V	2	916-010-35
C6	Cap, Mica, 510pF	1	915-035-11
C8, C9	Cap, Tant, 2.2 @ 35V		916-220-04
C10	Cap, .68mF Film	1	919-068-00
C11	Cap, 1mF Film	1	919-100-00
C12	Cap, .22mF Film	1	919-022-00
C13, C14, C17	Cap, Disc, .01 @ 50V	7	900-021-07
C18-C21			
CR1-CR5, CR7	Diode, 1N914	6	961-091-40
CR6	Diode, 6.4V	1	961-457-70
J1	Connector, PC7M	1	973-380-00
Q1	Transistor, 2N3415	1	962-341-50
R1, R2	Resistor, 1/4W 5% 20k	2	942-202-03
R3	Resistor, 1/4W 5% 100	2	942-201-01
R4	Resistor, 1/4W 5% 180	1	942-201-81
R5	Resistor, 1/4W 5% 10k	1	942-201-03
R6	Resistor, 1/4W 5% 100	1	942-201-01
R7	Resistor, 1/4W 5% 6.8k	1	942-206-82
R8, R9	Resistor, RN60C, 10k	2	920-410-02
R10	Pot, 10k Cermet	1	960-451-11
R11	Resistor, 1% 5.11k	1	920-475-01
R12	Resistor, 1/4W 5% 330k	1	942-203-34
R13, 14	Pot, 20k Cermet	2	960-012-11
R15, R16	Resistor, 1% 150k	2	920-415-03
R17	Resistor, 1/4W 5% 22M	1	942-202-26
R18	Resistor, 100k Cermet	1	960-011-18
R19	Resistor, 1/4W 5% 100k	1	942-201-04
R20	Resistor, 1% 100k	1	920-410-03
R21-R23	Resistor, 1/4W 5% 51k	3	942-205-13
R24	Resistor, 1/4W 5% 150k	1	942-201-54
R25	Resistor, 1/4W 5% 3.3k	1	942-203-32
R26	Resistor, 1/4W 5% 1M	1	942-201-05
R27, R28	Resistor, 1/4W 5% 10	2	942-201-00
R29	Resistor, 1/4W 5% 1k	1	942-201-02
T1	Transformer	1	967-020-10
TB1	Terminal Strip	1	973-010-32
Z1, Z3	IC, Hex Inverter 74C04	2	965-587-05
Z2	IC, Optical Isolator	1	965-570-00
Z4	IC, Mono-vibrator	1	965-587-72
Z5, Z19	IC, Dual Op. Amp.	2	965-617-00
Z6-Z8	IC, 8-bit Register	3	965-587-65
Z9	IC, 4-2 in NOR CMOS	1	965-587-01
Z10	IC, Quad Mux CMOS	1	965-587-06
Z11-14	IC, Quad Comparator	4	965-587-64
Z15	IC, Binary Counter	1	965-587-66
Z16-Z18	IC, BCD Counter	3	965-587-67
	Connector Cable	1	973-390-00

Series 400A, Basic Indicator Hardware

Description	Quantity	Part Number
Chassis, Die-cast	1	400-2010-05
Label, Input Terminals	1	400-2246-01
Label, Input Power (115VAC)	1	400-2247-00
Label, Input Power (230VAC)	1	400-2248-00
Rear Cover	1	400-2470-03
Bracket, Panel Mounting	1	400-2480-02
Label, Data Output Cover	1	400-2630-00
Front Panel, Red Plexiglass	1	400-2760-00
Label, Serial Tag	1	400-2795-00
Display Board to Case:		
Screw, PHMS 4-40 x 1/4	2	980-440-025
Washer, #4 Split Lock	2	986-200-04
Rear Grounding Screw:		
Screw, Panhd PH 6-32 x 5/8	1	980-632-063
Washer, #6 Star	1	986-200-06
Rear Cover to Case:		
Screw, Panhd PH 8-32 x 3/8	1	980-832-038
Washer, #8 Split Lock	1	986-200-08
Panel Mtg. Bracket to Case:		
Screw, Panhd PH 8-32 x 1/2	2	980-032-050
Plexiglass to Case:		
Screw, Fillister 4-40 x 3/8	2	982-4400-038
Grommet, Nyl 3/4, Rear Cover	1	991-056-25
Input Wires		
Plug, Bench Mount Holes	2	991-057-02
Power Cord	1	993-200-07

Power Pack, 406/407, Hardware

Description	Quantity	Part Number
Model 406 Front Panel Overlay	1	406-2040-01
Model 407 Front Panel Overlay	1	407-2040-01
Chassis, Die-cast, Battery Pk.	1	406-2010-05
Label, Serial Tag	1	400-2795-00
Case, Power Pack	1	407-2000-01
Rear Cover	1	407-2010-02
Label, Rear Cover Instruction	1	407-2070-01
Rear Cover to Case:		
Screw, Panhd PH 8-32 x 3/8	4	980-832-038
Washer, #8 Flat	4	986-100-08
Washer, #8 Split Lock	4	986-200-08
Handle, Power Pack Case	1	991-050-08
Handle to Case:		
Screw, Flathd PH 8-32 x 1/2	2	981-832-050
Foot, Adhesive Backed, Black	8	991-055-04
Front Panel, Battery Pack	1	407-2020-01
Battery Clamp	1	407-2030-01
Connector, Battery Plug	1	973-070-10
Binding Post, white	1	973-301-00
Binding Post, red	1	973-301-01
Battery Clamp to Panel:		
Screw, Panhd PH 6-32 x 3/8	2	980-632-038
Washer, #6 Star	2	986-400-06
Battery Clamp to PCB:		
Screw, Flathd PH 6-32 x3/8	4	981-632-038
Standoff, 1-1/2 x 6-32	2	991-020-77
Nut, Speed Nut 6-32	4	991-040-64
Voltage Regulator Heatsink:		
Heatsink	1	991-008-00
Heatsink Clip	1	991-040-49
Nut, #6 Hex	1	984-100-632
Knob (407)	2	991-050-05
I/O Cable, Power Pack	1	993-300-06

Application of the Series 400A digital indicators is broadened with the availability of a new PMOS LSI chip (K7503, order code LSID). The LSI chip, in conjunction with new analog programming modules, provides seven additional ranges as described in Table 1 below;

Table 1

Range Designator	LSI Chip Code	Type of Input	Range	400A/402A		410A/412A	
				Resolution	Accuracy**	Resolution	Accuracy**
0C	D	Tungsten 5% Rhenium - Tungsten 28% Rhenium Thermocouple	-8° to +2372°C	1°C	1.7°C	0.1°C	0.8°C
0N	D	Nicrosil - Nisil Thermocouple	32° to 2400°F 0° to 1315°C	1°F 1°C	1.5°F 1.0°C	0.1°F 0.1°C	0.6°F 0.4°C
CG	D	Chromel - Gold .07% At . Iron Thermocouple	0° to 280°k	1k	1.0k	0.1k	0.3k
P7	D	PT-100Ω, 4 wire α.00392 Platinum RTD, °C	-30° to +143°C	0.1°C	0.14°C	0.01°C	0.073°C
P8	D	PT-100Ω, 4 wire α.00392 Platinum RTD °F	-50°C to +262°F	0.1°F	0.27°F	0.01°F	0.141°F
N3	D	Ni-120Ω, 3 wire Nickel RTD†	-130° to +612°F -94° to + 322°C	1.0°F 1.0°C	1.0°F 1.0°C	0.1°F 0.1°C	0.4°F 0.2°C
N4	D	Ni120Ω, 4 wire Nickel RTD†	-118° to +612°F -83.4° to +322°C	1.0°F 1.0°C	1.0°F 1.0°C	0.1°F 0.1°C	0.4°F 0.2°C

**Include errors due to linearization, A/D conversion, internal instrument noise, and $\pm 10\%$ line voltage variation at $25 \pm 3^\circ\text{C}$ ($77 \pm 5^\circ\text{F}$) for 24 hours without zero or scale adjustment. All contributing errors are added together to produce worst case instrument accuracy.

†Linearization curve based upon Minco Table 7-120.

Note

For proper operation of the "C" range, the degrees F/C switch must be set to the "F" position. (Even though the range reads in degrees C.)

The calibration values and display readings for the new ranges are given in Table 2 below:

Table 2

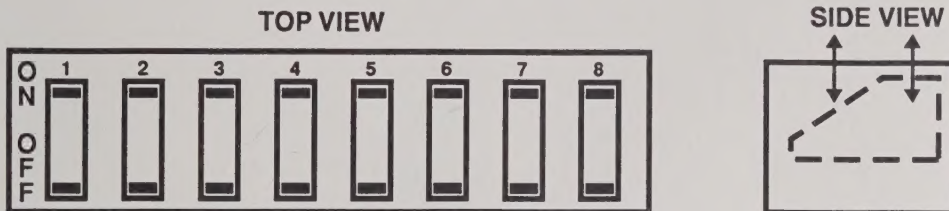
Range	Sensor Type	Input	Adjust	Read	Input	Adjust	Read	Input	Adjust	Read
C	Tungsten 5% Rhenium - Tungsten 26% Rhenium	0mV	Zero	0°C	37.107mV	+Span	2320°C	—	—	—
N	Nicrosil Nisil	0mV 0mV	Zero Zero	32°C 0°C	46.048mV 46.048mV	+Span +Span	2300°F 1260°C	— —	— —	— —
CG	Chromel - Gold .07% At. Iron	-5.256mV	Zero	5k	0.41mV	+Span	275k	—	—	—
P7	Platinum RTD $R_0=100\Omega$ 4 wire $\alpha= .00392$	100 Ω	Zero	0°C	154.62 Ω	+Span	140°C	90.00 Ω	-Span	-25°C
P8	Platinum RTD $R_0=100\Omega$ 4 wire $\alpha= .00392$	100 Ω	Zero	32°C	148.67 Ω	+Span	256°F	82.62 Ω	-Span	-46°F
N3	Nickel RTD $R_0=120\Omega$ 3 wire	120 Ω 120 Ω	Zero Zero	32°F 0°C	471.20 Ω 471.20 Ω	+Span +Span	608°F 320°C	66.60 Ω 66.60 Ω	-Span -Span	-112°F -80°C
N4	Nickel RTD $R_0=120\Omega$ 4 wire	120 Ω 120 Ω	Zero Zero	32°F 0°C	471.20 Ω 471.20 Ω	+Span +Span	608°F 320°C	66.60 Ω 66.60 Ω	-Span -Span	-112°F -80°C

The K7503 LSI chip also supports existing Platinum and Copper RTD, Thermistor, and linear current and voltage ranges with the use of the appropriate programming module. Calibration is described in Section 2 of the manual.

How to Actuate the Various DIP Switch Types

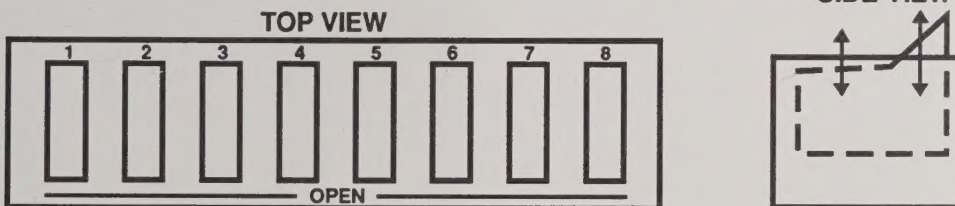
Your instrument may use one or more of the DIP switch types shown below. This addendum shows you how to actuate each type.

a. Recessed rocker type:



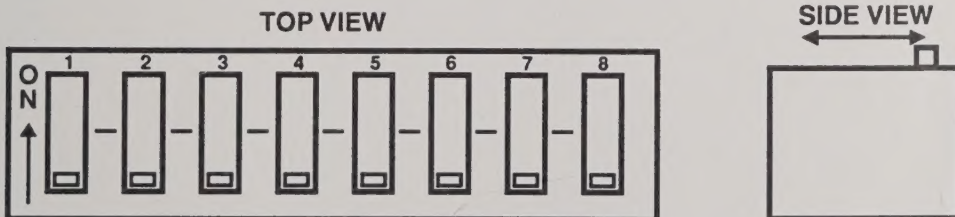
Push down on the "ON" side to set the switch ON/CLOSED.
Push down on the "OFF" side to set the switch OFF/OPEN

b. Raised rocker type:



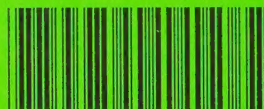
Push down on the numbered side to set the switch ON/CLOSED.
Push down on the "OPEN" side to set the switch OFF/OPEN.

c. Slide type:



Slide the tip toward the numbers to set the switch ON/CLOSED.
Slide the tip away from the numbers to set the switch OFF/OPEN.

MP MASTER



MA35663

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